DENISON UNIVERSITY BULLETIN

Volume XXVI, No. 6

JOURNAL

OF THE

SCIENTIFIC LABORATORIES

Volume XXI Articles 5-7 Pages 285 to 434

EDITED BY

W. C. EBAUGH

Permanent Secretary, Denison Scientific Association

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GRANVILLE, OHIO

SEPTEMBER, 1926

The University Bulletin is issued bi-monthly and is entered at the Post Office in Granville, Ohio, as mail matter of the Second Class

JOURNAL
OF THE
SCIENTIFIC LABORATORIES
OF
DENISON UNIVERSITY

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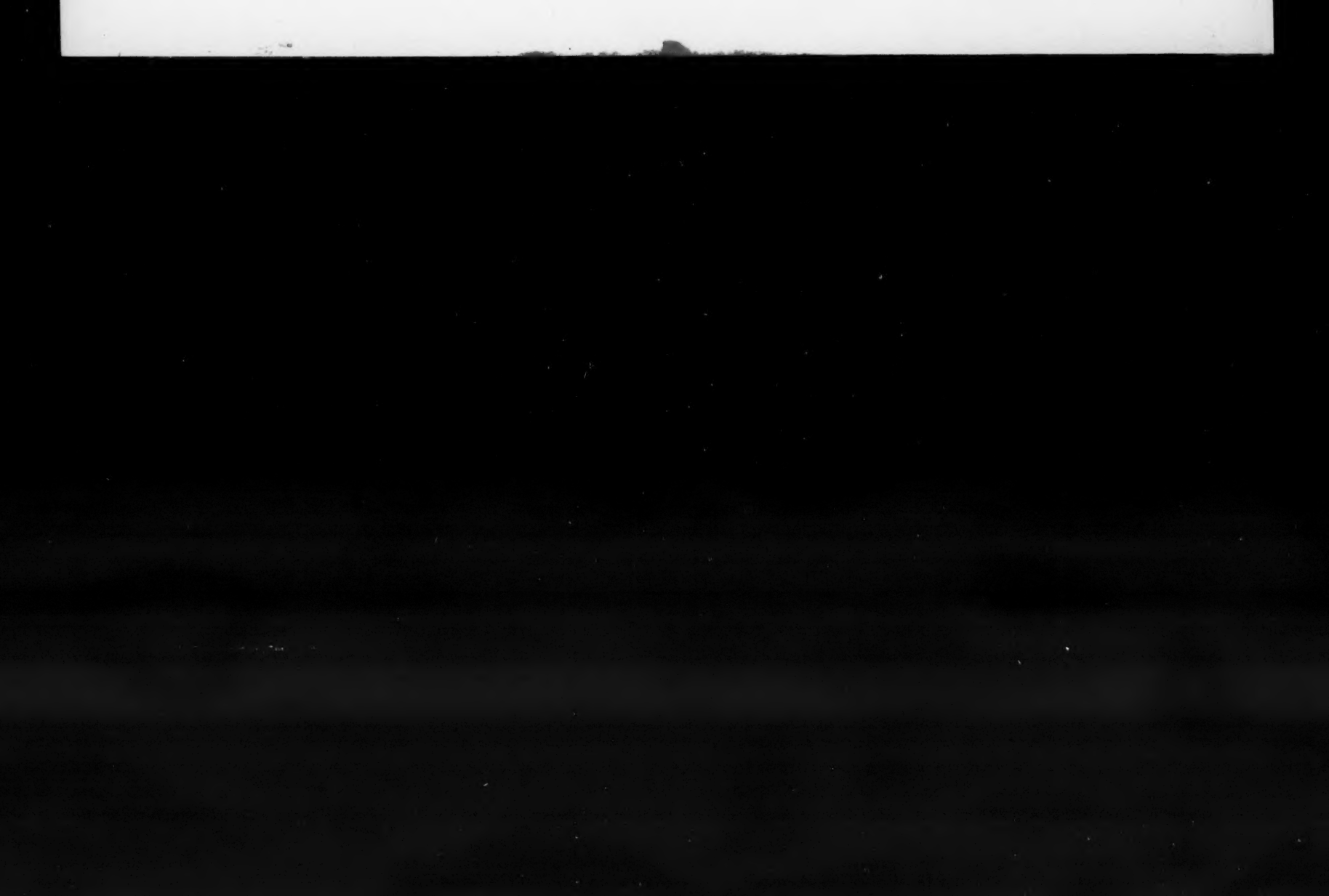

JOURNAL

OF THE

SCIENTIFIC LABORATORIES

OF

DENISON UNIVERSITY

EDITED BY

W. C. EBAUGH

VOLUME XXI

1925–1926

GRANVILLE, OHIO

Published
March, September, 1925; September, 1926

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Organized April 16, 1887

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The following officers served during the current year.

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In accordance with the Association's custom public meetings were held semi-monthly during the college year. The speakers and their topics are presented herewith.

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October

PERSONAL IMPRESSIONS OF PEKIN—W. M. GEWEHR
THE PHYSIOGRAPHIC HISTORY OF THE FOLDED APPALACHIANS—F. J. WRIGHT

November

GREEK FORTIFICATIONS AND WALLS—L. R. DEAN

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SYNTHETIC MEDICINALS—PHILIP C. SCHERER, JR.
THE PRESENT EUROPEAN SITUATION—C. F. WEST

February

SOURCES OF LONGFELLOW'S "GOLDEN LEGEND"—W. A. CHAMBERLIN

WHO AND WHAT ARE NORDICS?—F. G. DETWEILER

March

LOW POWERED RADIO COMMUNICATION—R. H. HOWE

FLORA AND FAUNA OF CENTRAL COLORADO—A. W. LINDSEY

April

MORPHOLOGY OF A LISZT SYMPHONIC POEM—K. H. ESCHMAN

PROBLEMS IN MODERN ASTROPHYSICS—PAUL BIEFELD

May

EMOTIONS—FOR WEAL OR WOE—T. A. LEWIS

MILITARY STRATEGY—CAPT. R. E. MCLAIN

Respectfully submitted,

W. C. EBAUGH, *Permanent Secretary*

ACTINOSIPHONATE, TROCHOCEROID AND OTHER CEPHALOPODS

AUG. F. FOERSTE

Received June 23, 1926; published September 29, 1926

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DESCRIPTION OF GENERA

(New genera are italicized)

I. Orthoconic genera: 1, *Laumontoceras;* 2, Jovellania; 3, Mixosiphonoceras; 4, Tripleuroceras; 5, *Allumettoceras;* 6, Tripteroceras; 7, *Murrayoceras;* 8, Lambeoceras; 9, Projovellania.

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ACKNOWLEDGMENTS

The writer is indebted to various individuals for assistance in his studies. Dr. Ray S. Bassler, of the U. S. National Museum, threw open to him the resources of this great museum. Irwin Pohl, on the staff of the same museum, took most of the photographs of the figures accompanying the original description of the species designated here as genotypes. Prof. Percy E. Raymond, of Harvard University, secured access for the writer to the wonderful collection of cephalopods gathered by Hyatt at the Museum of Comparative Zoology at that institution; and Mr. Samuel Henshaw of that museum graciously permitted the loan of a considerable part of this collection. The Harvard museum contains not only the excellent Day collection of Racine cepha-

lopods, but also the valuable Schary collection of Bohemian cephalopods, duplicating many of the species described by Barrande. Dr. Arthur Ware Slocom of the Walker Museum at Chicago University, Dr. Chester A. Reeds of the American Museum of Natural History, and Dr. E. M. Kindle of the Victoria Memorial Museum at Ottawa, Canada, also assisted by kindly loaning some of the valuable types in their care. Dr. F. A. Bather, head keeper of the British Museum, kindly prepared for the writer the casts of the two individuals of *Gomphoceras pyriforme* here figured. To all of these individuals the writer here expresses his most sincere thanks.

A. THE ACTINOSIPHONATA

The term *Actinosiphonata* was proposed by Hyatt[1] for those nautiloid cephalopods in which the interior of the siphuncle is lined with vertical lamellae which converge from the walls of the siphuncle toward its center, however without reaching the latter.

This structure appears to have been noted for the first time in 1842, when it was figured by d'Archiac and de Verneuil[2] in *Cyrtoceras depressum*. In 1845 it was figured by the same two authors[3] in *Mixosiphonoceras jovellani*. In 1850 it was described by one of these authors, de Verneuil,[4] in *Jovellania buchi*, though no figures of this structure were published until the species was illustrated by Bayle[5] in 1878. The next author to observe this structure was Sandberger,[6] who figured it in 1855 in the three species: *Coelocyrtoceras ventralisinuatum*, *Wissenbachia orthogaster*, and *Tripleuroceras triangulare*. In 1858 it was figured by Pacht[7] in *Mecynoceras rex* and *Pachtoceras rotundum*. It was figured in 1882 by Blake[8] in *Blakeoceras llandoveri*.

[1] Hyatt, in Zittel-Eastman's Text-book of Paleontology, 529, (1896).

[2] Trans. Geol. Soc. London, ser. 2, vol. 6, pl. 29, fig. 1a; (1842).

[3] Bull. Soc. Geol. France, 2nd ser., vol. 2, pl. 13, figs. 1b, 2; (1845).

[4] Bull. Soc. Geol. France, 2nd ser., vol. 7, p. 778; (1850).

[5] Explication de la Carte Geol. de France, vol. 4, Atlas, pl. 35 figs. 2, 3; (1878).

[6] Sandberger, Versteinerungen des Rheinischen Schichtensystems in Nassau, pl. 14, figs. 3a, 4, 4b; pl. 16, figs. 1a, 1b, 2b, 3a, 3b, 4a; (1855).

[7] Pacht, in Helmersen and Pacht, Beiträge zur Kenntniss des Russischen Reiches, vol. 21, pl. 1, figs. 2, 3, 4; pl. 2, figs. 2, 2a, 2b; (1858).

[8] Blake, British Fossil Cephalopoda, pl. 21, fig. 1a; (1882).

The first American species known to have this type of structure was described by Hall[9] in 1861, under the name *Cyrtoceras subrectum*, here used as the genotype of *Herkimeroceras*. Actinosiphonate structure possibly is indicated by the radiating lines along the strongly contracted part of the siphuncle, between its successive segments, in the figures of *Acleistoceras eximium* and *Acleistoceras mitra* published by Hall and Clarke[10] in 1888.

However, it is Barrande who did most to call attention to this type of structure, figuring and describing[11] between 1867 and 1877 fully 57 new species in which the siphuncle is lined with vertical converging lamellae. Moreover, toward the close of his studies he gave a résumé[12] of all information he had been able to collect regarding actinosiphonate species, including as complete a list of these species, from Bohemia and other countries, as he had at his command.

B. STRATIGRAPHIC DISTRIBUTION

Stratigraphically, the Actinosiphonata are known to range from the lower part of the Upper Ordovician to the Upper Devonian. Possibly they occur also in the Carboniferous, though the evidence at hand is not clear.

The oldest known described species are *Wetherbyoceras vallandighami* from the Cincinnati area, and *Wetherbyoceras conoidale* from western Tennessee. These two species are closely related, and occur at essentially the same horizon, the former in the Fairmount member of the Maysville, and the latter in the Leipers member of the same formation. However, one of these species, or possibly an undescribed third one, occurs also in the lower third of the Eden formation, which is the formation next beneath the Maysville.

The next actinosiphonate species, in point of age, appears to be *Diestoceras scalare* Foerste, from the Charleton member of the

[9] Pal. New York, vol. 3, pl. 69, figs. 3b, 3d; (1861).

[10] Pal. New York, Suppl. to vol. 5, pt. 2, in vol. 7, pl. 120, figs. 2, 3; pl. 121, fig. 3; (1888).

[11] Systeme Silurien du Centre de la Boheme, vol. 2; (1867–77).

[12] Loc. cit., part 5, 1082–86; (1877).

Richmond formation on Anticosti, the Richmond being immediately above the Maysville.

The earliest known European actinosiphonate species is *Blakeoceras llandoveri*, from the Lower Llandovery of Wales, a formation corresponding approximately to the Clinton of North America.

From his zone E in the Middle Silurian Barrande described 28 actinosiphonate species, of which 16 species belong to the trimeroceroid genera *Mandaloceras* (1), *Hemiphragmoceras* (4), *Tetrameroceras* (8), *Conradoceras* (1), *Hexameroceras* (1), and *Octameroceras* (1). The remaining 12 species belong to the genera *Mixosiphonoceras* (2), *Projovellania* (1), *Oocerina* (4), *Codoceras* (1), *Danaoceras* (1), *Protophragmoceras* (1), *Amphicyrtoceras* (1), and *Perimecoceras* (1), some of these generic references being merely provisional, as indicated in the body of the following text. This zone E of Bohemia corresponds approximately to the Racine of Wisconsin and northern Illinois.

Although the cephalopod fauna of the Racine of Wisconsin and Illinois, of the Cedarville dolomite of Ohio, and of the stratigraphically corresponding Guelph fauna in southern Ontario is large, actinosiphonate structure has been noticed so far only in *Hexameroceras* in the Racine, in a species identical with or closely related to *Hexameroceras septore* Hall (incorrectly referred to *Septameroceras*).

Eleven actinosiphonate species are regarded as of Lower Devonian age. Of these *Herkimeroceras subrectum* Hall is from the Keyser horizon of New York, at the base of the Lower Devonian. *Laumontoceras laumonti*, *Jovellania buchi*, and *Lorieroceras lorieri* are from France. *Mixosiphonoceras jovellani* is from northern Spain. *Ptenoceras alatum* is from division F2 in Bohemia. The remaining five species are included in the genus *Karoceras* proposed by Roussanoff, and were found on Nesnayemi Fjord on the eastern side of Novaya Zemblya; their reference to the Lower Devonian is only tentative.

Thirty-three actinosiphonate species are referred to the Middle Devonian. Of these, *Tripleuroceras triangulare*, *Tripleuroceras Roemeri*, *Wissenbachia orthogaster*, and *Cyrtoceras depressum* are

from Germany. *Acleistoceras eximium* and *Acleistoceras mitra* are from Ohio. And the remaining 27 species are from Bohemia. The latter include *Tripleuroceras archiaci, Tripleuroceras victor, Cyrtactinoceras? botulus, Conostichoceras palinurus, Conostichoceras laetificans, Adelphoceras bohemicum, Homoadelphoceras devonicans, Paracleistoceras devonicans, Poteriocerina lumbosum, Phragmoceras* (7 species), *Tubiferoceras? verneuili, Bolloceras* (6 species), *Blakeoceras empiricum, Turnoceras turnus, Paraconradoceras rigescens,* and *Nothoceras bohemicum.*

Two species, *Mecynoceras rex* and *Pachtoceras rotundum,* were described by Pacht from the Upper Devonian of the upper Don area of Russia.

The species described by Martin as *Orthoceratites Breynii* was later described by M'Coy[13] as having the "interior of the siphon traversed by a small continuous tube, attached to the inner walls of the dilated portion by radiating, vertical, shelly partitions (about eight in a whorl), constricted by transverse stronger partitions in the middle of each dilation (or segment)." The small number of vertical lamellae suggests an actinosiphonate structure while the transverse partition in the middle of each dilation is distinctly an actinoceroid structure, so that this Lower Carboniferous species is regarded as actineroceroid, rather than actinosiphonate.

Among the species listed by Barrande[14] as having vertical converging lamellae, it is probable that several should be listed as actinoceroid instead. For instance, *Orthoceras nummularium,* identified by Schmidt[15] from the Tamsal formation at the base of the Silurian of Esthonia, unquestionably is an actinoceroid. The species described by Schmidt (on the same page) as *Orthoceras laeve,* from the Kunda formation in the Lower Ordovician of the same country, apparently is another actinoceroid. The figures of *Thoracoceras distans* provided by Fischer and Eichwald[16]

[13] M'Coy, in A Synopsis of the Classification of the British Palaeozoic Rocks, by Rev. Adam Sedgwick, 567; (1854).

[14] Systeme Silurien du Centre de la Boheme, part 5, 1082–86; (1877).

[15] Schmidt, Untersuchungen ueber die Silurische Formation von Ehstland, Nord Livland und Oesel, 196; (1858).

[16] Fischer, Oryctographie du Gouv. de Moscou, pl. XI, fig. 10; (1830–37). Eichwald, Lethaea Rossica, pl. 48, figs. 2a, 2b; (1859–60).

leave the exact structure of the interior of its siphuncle in doubt; however, there is no known reason why it should be referred to the Actinosiphonata.

C. GEOGRAPHIC DISTRIBUTION

The geographical distribution of the Actinosiphonata, as far as known, is chiefly European, especially middle European, in an east and west direction. One species is known from northern Spain, one from Wales, three from northwestern France, one from the Eifel area in western Germany, another from the Nassau area directly eastward, and a third from the Harz area, northeastward; the last three, in Germany. In Bohemia, south of the eastern half of Germany, 56 actinosiphonate species are known. From the upper Don area, south of the central part of Russia, only 2 species are known. Far removed from the upper Don area, about 1500 miles east of north, is that exposure on the eastern side of Novaya Zemblya which furnished the 5 species of *Karoceras,* all of which have actinosiphonate siphuncles. Since the Ural mountain area is characterized by Devonian faunas showing Bohemian affinities, it is possible that eventually the Novaya Zemblya fauna containing *Karoceras* also may show Bohemian affinities.

From the stratigraphical standpoint it may be noted that the British formation containing an actinosiphonate cephalopod is of lower Silurian age. The French and Spanish deposits noted above are of Lower Devonian age. The German and Bohemian deposits are of Middle Devonian age. And the deposits from the upper Don area are of Upper Devonian age. Whether there is any significance in the rise of the stratigraphical position of the geological formations in which actinosiphonate cephalopods occur, in passing from western Europe eastward, can not be determined in the present state of our knowledge.

In North America, actinosiphonate species are known from Tennessee, the Cincinnati area, Anticosti, Racine, New York, and Ohio, naming the states in the stratigraphical order of succession of the species cited on a preceding page from these areas.

D. AREA OF ORIGIN

Considered from the standpoint of range of generic variation, Bohemia offers 29 genera of actinosiphonate cephalopods. Germany and France offer 3 each, and the remaining states, either of Europe or of America, offer only 1 or 2 each. From this it is evident that Bohemia, although possibly not the center of origin of the Actinosiphonata, was the great center of variation, and possibly also of dispersal, during the Middle Silurian and Middle Devonian at least.

The area of origin of the Actinosiphonata can not be determined from the meager evidence at hand. Neither *Wetherbyoceras* nor *Diestoceras* are regarded as direct ancestors of any of the various genera known in Europe. They are much more likely to be strongly divergent off-shoots from the main line of descent. The mere fact that the Actinosiphonata are represented in America by two genera which occur there much earlier than any species now known in Europe is not conclusive evidence that the Actinosiphonata originated in America, rather than in Europe.

E. FORM OF SEGMENTS OF SIPHUNCLE

It was noted already by Barrande that almost all actinosiphonate species have relatively broad siphuncles. To this there are only two known exceptions: *Ptenoceras alatum*, and *Lorieroceras lorieri*, to be discussed later.

In those species with relatively broad siphuncles, the segments of the siphuncles may be distinguished as cylindroid, globular, or nummuloid.

E1. Species with cylindroid segments

By cylindroid segments are meant those segments of the siphuncle which enlarge only moderately within the camerae, the enlargement being not sufficient to give rise to globular or nummuloidal outlines. In most species with cylindroid segments it has not been possible to differentiate the septal necks from the connecting rings with any degree of certainty. As a rule, vertical sections of the siphuncle present vertical outlines in which the

septal neck continues into the connecting ring without any visible break, though theoretically such a break should exist.

The species with cylindroid segments include *Laumontoceras laumonti, Jovellania buchi, Mixosiphonoceras desolatum, Mixosiphonoceras infelix, Danaoceras danai, Herkimeroceras subrectum, Wissenbachia orthogaster, Poteriocerina lumbosum, Pachtoceras rotundum, Hemiphragmoceras globulosum, Tetrameroceras discrepans, Tetrameroceras loveni, Tetrc meroceras infaustum, Tetrameroceras vetus, Tetrameroceras deshayesi, Conradoceras conradi,* and *Hexameroceras panderi.*

E2. Species with nummulo-cylindroid segments

From those cylindroid segments in which the lateral diameter does not conspicuously exceed their height, to those in which this lateral diameter is conspicuously greater there is every gradation. In *Codoceras indomitum* all stages of change are shown in a single individual, its segments being cylindroid near the base of the siphuncle, but conspicuously wider than high toward its top. Specimens with the nummulo-cylindroid outline of the segments include *Tripleuroceras archiaci, Projovellania solitarium,* and *Hemiphragmoceras pavidum.* In *Mixosiphonoceras jovellani* the septal necks appear to be unusually long, giving the segments a vertical outline not known in any other species. Possibly *Protophragmoceras beaumonti* should be included among species having a nummulo-cylindroid outline in its segments.

E3. Species with globular segments

In segments with globular outlines, the constrictions at the septal necks are relatively abrupt and conspicuous. In these species, although the outline is globular, the height of the segments commonly is less than their width, owing to the apparent truncation of these segments both at their tops and their bases. When the siphuncle is located close to the ventral side of the conch, the outline of the segments is globular only in transverse lateral sections, being distinctly oblique in dorso-ventral vertical sections. Species with this type of structure include *Wetherby-*

oceras vallandighami, Wetherbyoceras conoidale, Oocerina lentigradum, Oocerina stygiale, and *Coelocyrtoceras ventralisinuatum.*

E4. Species with nummuloidal segments

The species with the more typical nummuloidal segments are strongly constricted at the septal necks, where the septa usually are adnate for an appreciable distance to the lower surface of the immediately overlying segment. The general outline of the segments is flattened and disk-like, rather than globular. Among species having this type of segments are *Acleistoceras eximium, Acleistoceras mitra, Mandaloceras bohemicum,* and *Mandaloceras verneuili.*

E5. Variations from nummuloidal outlines

Some very peculiar outlines occur in the segments of the siphuncles of certain actinosiphonate species.

For instance, in *Oocerina abditum* and *Oocerina strangulatum* these segments enlarge toward their base, the latter being more or less adnate to the septum immediately beneath. In *Conostichoceras palinurus,* and possibly also in *Conostichoceras laetificans,* this is true to such a conspicuous degree that the outline varies between a truncated cone and a pestle with almost all of its handle cut off.

In *Mecynoceras rex* the segments as nearly cylindrical along their lower and upper thirds, but the median third is enlarged conspicuously in an annular manner.

In typical *Amphicyrtoceras* the outline of the segments is narrowly barrel shaped, either cylindrical or faintly enlarging toward mid-height. In the species here listed as *Amphicyrtoceras* (?) *penultimum,* however, these segments contract slightly toward mid-height. At their top and bottom the segments of all species referred to this genus contract abruptly and deeply, the septal necks being very short.

E6. Segments with straight or concave vertical outlines

In several phragmoceroids, the vertical outline of the segments of the siphuncle appears to be straight, or almost straight.

Among these are the species *Phragmoceras dux*, *Phragmoceras inflexum*, and *Phragmoceras comes*, all Middle Devonian species.

However, the most peculiar structure among actinosiphonate cephalopods is that in which the vertical outline of the segments of the siphuncle curves more or less distinctly inward. Such an outline is figured by Barrande in the case of *Paraconradoceras rigescens*, a gomphoceroid. It occurs also in *Perimococeras contrastans*, *Blakeoceras empiricum*, and *Blakeoceras llandoveri*, which are laterally compressed cyrtoceroids; also in *Turnoceras turnus*, which is a dorso-ventrally depressed cyrtoceroid; and in *Nothoceras bohemicum*, which is a nautiloid shell.

Usually, this inward curvature of the vertical outlines of the segments of the siphuncle is confined to holochoanoidal species. but there is no reason to believe that any of the species just cited are holochoanoidal in structure. However, it is desirable that the species whose siphuncular segments have concave vertical outlines be subjected to further study.

E7. Species with scalariform siphuncles

In numerous cyrtoceroids, the siphuncle, when located close to the ventral side of the conch, has the ventral side of its segments more or less protuberant toward its base, so as to approach more nearly toward the ventral wall of the conch. Not infrequently this protuberant base is attached for an appreciable distance to the upper surface of the immediately underlying septum. In a corresponding manner, the dorsal outline of the segments may slope away from the ventral outline of the conch, so that the upper part of this outline is more remote from the ventral outline of the conch. In that case the upper part of this segment often is attached to the lower surface of the septum immediately above, for an appreciable distance. When these ventral and dorsal outlines of the segments are relatively straight, a stair-like effect is produced, which is here indicated by the term scalariform.

Among the actinosiphonate species with a scalariform siphuncle is *Diestoceras scalare* Foerste from the Charleton member of the Richmond formation, on Anticosti. In this species the vertical outlines of the segments of the siphuncle appear relatively

straight, though obliquely inclined. In two specimens of *Cyrtoceras*, belonging to the U. S. National Museum, apparently closely related to *Cyrtoceras depressum*, the scalariform type of siphuncle appears to be present. This structure is indicated more clearly on the ventral side of the siphuncle than along its dorsal side, the vertical outline of the segments tending to be slightly concave dorsally. In both specimens of *Cyrtoceras* the septal necks are clearly defined, but the direction of the connecting rings can be determined only from the adjacent deposits, either on the inside or outside of the siphuncle.

Among the actinosiphonate species described from Novaya Zemblya,[17] a species of undetermined generic relationship described under the name *"Cyrtoceras" nesnayemiense*, has a scalariform siphuncle. In the more typical species of *Karoceras*, from the same locality, the dorso-ventral sections of the segments present vertical outlines which are intermediate in form between fusiform and scalariform.

E8. Species with fusiform segments

It was noted already by Barrande that almost all actinosiphonate cephalopods have relatively broad siphuncles, the form of their segments varying between cylindroid, globular, and nummuloid. However, a few species are known in which the segments have relatively narrow fusiform outlines. One of these is the gyroceroid species *Ptenoceras alatum*. Another is the trochoceroid species *Lorieroceras lorieri*, in which the outline is fusiform, but with the larger end of each segment directed downward or backward.

F. EXTENT OF ACTINOSIPHONATE STRUCTURE AMONG THE ACTINOSIPHONATA

As has already been pointed out in the preceding paragraph, actinosiphonate structure may occur in relatively narrow siphuncles with fusiform segments. It should be noted that si-

[17] Foerste, Report of Scientific Results of Norwegian Expedition to Novaya Zemblya, 1921, No. 31, 28; (1925).

phuncles of *Ptenoceras* and *Lorieroceras* are not of such a character as to suggest relationship to the *Cyrtochoanites*, the suborder of which the *Actinosiphonata* form merely one of the two subdivisions, the other being the *Annulosiphonata*. Hyatt was aware of this, as is shown by his reference of *Ptenoceras* to the *Orthochoanites*. He probably would have placed *Lorieroceras* also among the *Orthochoanites*, if he had established the latter as a distinct genus.

The most striking fact about the use of the term Actinosiphonata by Hyatt is that he included under this term 27 genera, more than half of which do not show any actinosiphonate structure in any species described so far.

Among these genera two, Eremoceras[18] and Cyclostomiceras,[19] are regarded by the present writer as belonging to the *Holochoanites*.

Among the genera lacking the actinosiphonate structure, the following have more or less fusiform segments of the siphuncle: *Rizoceras*, *Cyrtorizoceras*, *Oonoceras*, *Oncoceras*, and *Maelonoceras*. In *Poterioceras* the segments are elongate elliptical and much larger than in the preceding genera. In *Clinoceras* the segments are narrowly cylindrical, but abruptly contracted at the septal necks. In *Streptoceras* the segments are similar in form to those of Amphicyrtoceras,[20] having vertical outlines like those of short cylindrical barrels, abruptly contracted at the septal necks. *Trimeroceras*, *Pentameroceras*, *Septameroceras*, and *Gomphoceras* belong to the gomphoceroid group of cephalopods.

Unfortunately it can not be determined whether there is such a genus as *Septameroceras*. The genotype, *Gomphoceras inflatum* Billings, never was described and can not be found in the collections of the Geological Survey of Canada, in the Victoria Memorial Museum. According to Whiteaves[21] the aperture of this genotype was badly preserved. The species described by Hall as *Gomphoceras septoris* is an *Hexameroceras*, in which the

[18] Journal Sci. Labs. of Dension Univ., 19, 263, pl. 33, figs. 2, 8; (1921).
[19] Journal Sci. Labs. of Dension Univ., 20, 205; (1924).
[20] Journal Sci. Labs. of Denison Univ., 20, 255, pl 30, fig. 1D; (1924).
[21] Palaeozoic Fossils, Geol. Surv. Canada, vol. 3, pt. 2, 102.

supposed azygous dorsal sinus of the genotype was due to the spalling off of the median part of the dorsal crest of the living chamber.

G. EXTENT OF ACTINOSIPHONATE STRUCTURE AMONG SPECIES OF THE SAME GENUS

One of the most disconcerting elements in the attempt to discriminate genera among the numerous cyrtoceroid cephalopods is the uncertainty whether the presence or absence of actinosiphonate structure is to be regarded as a constant feature among species of the same genus. For instance, in *Projovellania athleta* no actinosiphonate structure is known, but it occurs in the species described by Barrande as *Cyrtoceras solitarium*, which may be congeneric. Actinosiphonate structure occurs in typical species of *Oocerina* as here defined, but is not known in all species referable to this genus on account of the form of their conchs and the globular or nummuloidal enlargement of the segments of their siphuncles. Actinosiphonate structure is present in typical *Karoceras*, but apparently not in all species referable to this genus. It is present in *Danaoceras danai*, but not in the closely related species described by Barrande under *Cyrtoceras insociale*. It is absent in the genotype *Protophragmoceras murchisoni*, but present in the closely related species described by Barrande under *Cyrtoceras beaumonti*. It is absent in typical *Amphicyrtoceras*, but is present in the species described by Barrande as *Cyrtoceras penultimum*, which possibly is related. It is absent in all Silurian species of *Phragmoceras*, but appears to be common among Devonian species referred to this genus by Barrande. In the same manner, it is absent in the Silurian species of *Tubiferoceras*, but is present in the similar species described by Barrande under *Phragmoceras verneuili*. It is absent in the genotype *Mandaloceras bohemicum*, but is present in the species described by Barrande as *Gomphoceras verneuili*. It is present in some forms of *Hexameroceras* but absent in others. It appears to be present in some species of *Diestoceras* but absent in others.

H. PREVALENCE OF ACTINOSIPHONATE STRUCTURE IN INDIVIDUALS OF THE SAME SPECIES

Unfortunately, as far as known, no studies have been made to determine the constancy with which actinosiphonate structure appears in individuals of the same species. The present writer has had the opportunity of studying the degree of constancy of this structure only in two species. One of these is the species of *Wetherbyoceras* occurring at the Leipers horizon in Kentucky and Tennessee. In this species the actinosiphonate structure always was found in specimens well enough preserved to have retained this structure. The other species was *Hexameroceras septoris* (incorrectly referred to *Septameroceras* by authors). Of this species only 2 specimens with actinosiphonate structure are known at present, the great majority not exhibiting it.

I. ACTINOSIPHONATE DISTINGUISHED FROM ANNULOSIPHONATE STRUCTURE

Annulosiphonate structure is typified by *Actinoceras*. In this and related genera calcareous deposits are formed within the siphuncle, beginning at the septal necks and gradually encroaching upon the interior of the intervening segments of the siphuncle. In its initial stages of growth this deposit forms an annulation on inner side of each septal neck, grooved along its exterior face by this neck. In vertical radial sections through the siphuncle, these deposits appear as lunate sections enveloping the inner outline of the necks. As the deposits increase in thickness they not only encroach upon the interior of the siphuncle but approach each other, meeting usually above mid-height of the intervening segments of the siphuncle. The lunate deposition of these deposits usually is well shown by all vertical radial sections through the siphuncle. Radial lines of deposition usually are indicated much more obscurely, though occasionally very distinct. They were figured, for instance, by Stokes in *Huronia vertebralis*, and are suggested by his figures of *Ormoceras bayfieldi*, and *Armenoceras sphaeroidale*. These radial lines, however, do not continue from one septal neck deposit through into the next,

but terminate a little above mid-height of the segments of the siphuncle, where the successive deposits meet.

In the Actinosiphonata, there is no continuous ring-like form of deposition, enveloping the septal necks. Instead, the deposits consist of vertical lamellae converging toward the center of the siphuncle but definitely separated laterally by narrow interspaces. In a few species, like *Laumontoceras laumonti, Mandaloceras verneuili,* and *Diestoceras scalare* these vertical lamellae appear to originate definitely at the septal necks. In a number of other species, including *Mixosiphonoceras desolatum, Oocerina lentigradum, Blakeoceras empiricum,* and *Turnoceras turnus,* the vertical lamellae appear to be interrupted somewhere in the vicinity of the septal necks. In most actinosiphonate species, however, these vertical lamellae, as far as known, are more or less continuous, without interruption above mid-height of the segments of the siphuncle.

In this connection, however, especial attention should be given to *Conostichoceras palinurus,* in which the figure of the exterior of the deposit within one of the segments of the siphuncle is figured by Barrande as interrupted at mid-height of the segment, immediately above the basal annulation, by a transverse line, which resembles that produced by the meeting of deposits on successive septal necks in the Annulosiphonata.

Evidently, it is desirable that the deposits within the interior of both the Annulosiphonata and the Actinosiphonata be subjected to further study from the point of view both of their origin and their progressive development, in order to learn whether these two subdivisions do not include a greater number of lines of variation than suspected at present.

J. THE VALUE OF ACTINOSIPHONATE STRUCTURE IN THE SYSTEMATIC CLASSIFICATION OF CEPHALOPODS

If the term Actinosiphonata be used to include only those genera in which the presence of actinosiphonate structure is definitely known, an assemblage results which apparently forms a natural group. This is true especially if the two species with narrow, fusiform segments of the siphuncle, namely *Ptenoceras*

alatum and *Lorieroceras lorieri*, be excluded. It then becomes necessary to determine whether any of the species not presenting an actinosiphonate structure should be included. Apparently this is the case. Under what pretext could the actinosiphonate species of *Phragmoceras* in the Devonian of Bohemia be placed in a different subdivision from typical Silurian species in which this type of structure does not occur? Finally, it remains to be determined whether any of the species with narrow fusiform siphuncles, such as *Rizoceras*, *Cyrtorizoceras*, *Oonoceras*, *Oncoceras*, or *Maelonoceras*, should be included. In the present state of our knowledge, it is difficult to see how the inclusion of the latter can be justified.

Evidently much further knowledge must be accumulated before this problem can be attacked intelligently. The purpose of this paper is to state the difficulties encountered at present.

In the present state of our knowledge it is not certain that actinosiphonate structure is to be found in all specimens of the same species whenever found in one of these specimens. Possibly it is not always preserved even if formerly present; at any rate, it is not always found, even when the state of preservation appears favorable.

Frequently actinosiphonate structure is shown by some species of a genus while absent in other species referable to the same genus. Therefore a classification based upon the presence or absence of actinosiphonate structure encounters serious difficulties.

On the other hand, it must be acknowledged that with the exception of a few genera, such as *Ptenoceras* and *Lorieroceras*, nearly all actinosiphonate cephalopods belong to the Cyrtochoanites, and that in this suborder they form a division separable from the Annulosiphonata. A difficulty, however, arises when it appears necessary to insert among the Actinosiphonata individual specimens, and even entire species, possibly even entire genera, in which no actinosiphonate structure is known.

K. THE VALUE OF CONCAVOSIPHONATE STRUCTURE FOR SYSTEMATIC CLASSIFICATION

Under section E6 it has already been stated that in certain species the segments of the siphuncle present concave vertical

outlines. These species are here referred to the genera *Perimecoceras, Blakeoceras, Turnoceras,* and *Nothoceras.* Possibly *Cyrtoceras* belongs to this group. Apparently all of these genera belong to groups in which normal nummuloidal siphuncles prevail, and there is no evidence that they belong to a separate group. The structure itself may be called concavosiphonate, in distinction from actinosiphonate and annulosiphonate.

L. THE GENERIC CLASSIFICATION OF THE ACTINOSIPHONATA

Any attempt at a natural classification of the nautiloid cephalopods is hampered very much by the broad signification formerly given to such terms as *Orthoceras, Cyrtoceras, Gyroceras, Nautilus, Gomphoceras,* and *Poterioceras.* Though these terms proved very convenient for many years, the number of species referable to them, when broadly used, is so great that it is impossible to indicate closer genetic relationship by their means. In later years many new genera were proposed, especially by Alpheus Hyatt, but their number is still inadequate. Moreover, some of Hyatt's genera never were described, though their genotypes were indicated. To many, the magnificent volumes on Bohemian Silurian and Devonian cephalopods, published by Barrande, are not constantly accessible. On this account the writer presents here brief descriptions of the genotypes of the genera recently studied, with figures taken wherever possible from the original publications. Around these genotypes then can be assembled those species having similar structures.

The material here discussed consists chiefly of those genera included by Hyatt in his Actinosiphonata. The presence of actinosiphonate structure in *Lorieroceras* and *Ptenoceras* led incidentally to a study of such trochoceroid material as was readily available.

A few notes on the family relationships of some of these genera have been added, but this will require a much more detailed discussion than is possible in the present paper.

M. LIST OF KNOWN ACTINOSIPHONATA

A. Segments of siphuncle with convex or nearly straight vertical outlines

1. Laumontoceras laumonti Barrande
2. Jovellania buchi Verneuil
3. Mixosiphonoceras desolatum Barrande
4. Mixosiphonoceras infelix Barrande
5. Mixosiphonoceras jovellani Verneuil and Archiac
6. Tripleuroceras archiaci Barrande
7. Tripleuroceras victor Barrande
8. Tripleuroceras triangulare Archiac and Verneuil
9. Tripleuroceras roemeri Foerste
10. Projovellania (?) solitarium Barrande
11. Karoceras typicum Foerste
12. Karoceras explicatum Foerste
13. Karoceras unguiforme Foerste
14. Karoceras triangulare Foerste
15. "Cyrtoceras" nesnayemiense Foerste
16. Wissenbachia orthogaster Sandberger
17. Oocerina lentigradum Barrande
18. Oocerina stygiale Barrande
19. Oocerina (?) abditum Barrande
20. Oocerina (?) strangulatum Barrande
21. Wetherbyoceras conoidale Wetherby
22. Wetherbyoceras vallandighami Miller
23. Herkimeroceras subrectum Hall
24. Pachtoceras rotundum Pacht
25. Mecynoceras rex Pacht
26. Amphicyrtoceras (?) penultimum Barrande
27. Paracleistoceras devonicans Barrande
28. Acleistoceras eximium Hall
29. Acleistoceras mitra Hall
30. Cyrtactinoceras (?) botulus Barrande
31. Conostichoceras palinurus Barrande
32. Conostichoceras laetificans Barrande
33. Poteriocerina lumbosum Barrande
34. Protophragmoceras (?) beaumonti Barrande
35. Danaoceras danai Barrande
36. Codoceras indomitum Barrande
37. Coelocyrtoceras ventralisinuatum Sandberger
38. Phragmoceras dux Barrande
39. Phragmoceras inflexum Barrande
40. Phragmoceras comes Barrande
41. Phragmoceras baro Barrande
42. Phragmoceras princeps Barrande
43. Phragmoceras hospes Barrande
44. Phragmoceras bohemicum Barrande

45. Bolloceras rex Barrande
46. Bolloceras pigrum Barrande
47. Bolloceras gutturosum Barrande
48. Bolloceras clypeatum Barrande
49. Bolloceras (?) bolli Barrande
50. Bolloceras (?) forbesi Barrande
51. Tubiferoceras (?) verneuili Barrande
52. Mandaloceras verneuili Barrande
53. Hemiphragmoceras pusillum Barrande
54. Hemiphragmoceras pavidum Barrande
55. Hemiphragmoceras globulosum Barrande
56. Hemiphragmoceras saturum Barrande
57. Tetrameroceras bicinctum Barrande
58. Tetrameroceras discrepans Barrande
59. Tetrameroceras loveni Barrande
60. Tetrameroceras infaustum Barrande
61. Tetrameroceras problematicum Barrande
62. Tetrameroceras vetus Barrande
63. Tetrameroceras insolitum Barrande
64. Tetrameroceras deschayesi Barrande
65. Conradoceras pseudoconradi Foerste
66. Hexameroceras panderi Barrande
67. "Hexameroceras" of septore (Hall) group
68. Octameroceras callistoma Barrande
69. Ptenoceras alatum Barrande
70. Adelphoceras bohemicum Barrande
71. Homoadelphoceras devonicans Barrande
72. Lorieroceras lorieri Barrande

B. Segments of siphuncle with concave vertical outlines

73. Perimecoceras contrastans Barrande
74. Blakeoceras empiricum Barrande
75. Blakeoceras llandoveri Blake
76. "Diestoceras" scalare Foerste
77. Cyrtoceras depressum Goldfuss
78. Turnoceras turnus Barrande
79. Paraconradoceras rigescens Barrande
80. Nothoceras bohemicum Barrande

I. ORTHOCONIC GENERA

Hyatt included among the Jovellanidae the 4 genera *Jovellania*, *Mixosiphonoceras*, *Tripleuroceras*, and *Projovellania*. These form a heterogeneous group. *Jovellania* and *Mixosiphonoceras* are alike in being depressed dorso-ventrally, with a tendency toward angulation along the median part of the ventral side, and the

siphuncle is ventrad in location. In *Jovellania* the conch is less depressed, and the surface of the conch is annulated. These two genera form the typical Jovellanidae.

In *Tripleuroceras* the ventral side is flattened, and the dorsal side is convex or more or less angulate; the siphuncle is nummuloid, and ventrad in location. Three Ordovician genera, *Allumettoceras*, *Tripteroceras*, and *Murrayoceras*, present similar cross-sections, but the interior of their siphuncles does not present converging vertical lamellae, and they are not known to be ancestral to *Tripleuroceras*. Provisionally these genera are included under the *Tripleuroceratidae*, with *Tripleuroceras* as the type of the family.

This leaves a number of genera unassigned. *Lambeoceras* presents a depressed lenticular cross-section, with the siphuncle in contact with its ventral side, its segments being nummuloidal. Its closest known relationship appears to be with *Allumettoceras*.

Projovellania is unlike the other genera here discussed in being laterally compressed, instead of dorso-ventrally depressed.

Laumontoceras is unlike the other genera here discussed in being circular in cross-section, with a central location for the siphuncle.

The presence of converging vertical lamellae within the siphuncle of the Silurian and Devonian genera here named is their most interesting feature, causing them to be united by Hyatt into a single group, the Jovellanidae, placed first among his Actinosiphonata.

1. **Laumontoceras** Gen. nov.

Plate XXXII, fig. 1

Genotype: *Orthoceras Laumonti* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, 1874, p. 680, pl. 235.

Conch straight, cross-section circular, location of siphuncle central. Segments of siphuncle cylindroid in outline, slightly contracted at the septal necks. The inner surface of these septal necks is embraced by an annular series of short converging vertical lamellae, whose inner margins present lunate outlines, suggestive

of the inner margins of vertical sections through the annular deposits enveloping the inner surface of the septal necks of Actinoceroids. In *Laumontoceras*, however, these deposits consist of discrete vertical lamellae instead of a continuous ring. The exact origin of this specimen was not known to Barrande, but was supposed to be from Nehou, Manche, France; in which case it is from the Lower Devonian.

2. **Jovellania** Bayle

Plate XXXII, figs. 2 A, B

Genotype: *Orthoceratites Buchii* de Verneuil, Bull. Soc. Geol. de France, ser. 2, vol. 7, 1850, p. 778. See also Bayle, Explication de la Carte Geol. de France, vol. 4, Atlas (text never published), 1878, pl. 35, figs. 1–3; and Foord, Catalogue of Fossil Cephalopoda in British Museum, pt. 1, 1888, p. 333.

Conch straight, transversely annulated. The annulations are present not only on the surface of the shell, but leave their impress also on the surface of the cast of its interior. Cross-section nearly circular, but slightly depressed dorso-ventrally, with the ventro-lateral sides sufficiently flattened to make the median part of the ventral side slightly angulate. The sutures of the septa are directly transverse. The siphuncle is located halfway between the center of the conch and its ventral wall. The segments of the siphuncle are cylindroid in outline, and are but slightly contracted at the septal necks. Their interior is occupied by converging vertical lamellae. From Nehou, Manche, France; in the Lower Devonian.

Since Bayle did not describe the genus *Jovellania*, nor refer to the specimen described by de Verneuil, but merely applied this generic name to the specimens he figured in the Atlas, the latter here are regarded as the true genotypes.

3. **Mixosiphonoceras** Hyatt

Plate XXXII, figs. 3 A–D

Genotype: *Cyrtoceras desolatum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 135, pl. 513. See

also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 529.

Conch enlarging slowly; cross-section depressed dorso-ventrally, somewhat elliptical transversely, but sufficiently flattened ventro-laterally to be slightly angulate along the median part of the ventral side. The sutures of the septa curve slightly downward ventro-laterally, but rise slightly along the median part of the ventral side. The siphuncle is located a little less than halfway between the ventral angle of the conch and its center. Its segments are cylindroid, being but moderately contracted at the septal necks. The interior of the siphuncle is occupied by converging vertical lamellae. Only one specimen is known. This is crushed dorso-ventrally. In its present condition it appears slightly curved lengthwise, with its ventral outline concave; however, if *Orthoceras infelix* is congeneric, the original form of *Mixosiphonoceras desolatum* also may have been straight. From Dvoretz, Bohemia: in the Middle Silurian; at Barrande's horizon e2. Plate XXXII, figs. 3 A–D.

Orthoceras infelix Barrande (loc. cit., p. 211, pl. 525), from the same horizon at Lochkov, Bohemia, differs chiefly in having a more triangular cross-section, the dorsal side being flatter, and the lateral angles more remote from the medio-ventral angle. The siphuncle is relatively smaller, and is nearer to the ventral angle, but its segments are similar to those of the preceding species in being cylindroid, and in containing converging vertical lamellae.

Orthoceratites Jovellani de Verneuil and d'Archiac (Bull. Soc. Geol. de France, ser. 2, vol. 2, p. 461, pl. 13, figs. 1, 1a) has a slowly enlarging straight conch, depressed dorso-ventrally, the dorsal side being much flatter than in *Mixosiphonoceras desolatum*, while its ventral side is almost evenly semicircular. In consequence, the dorso-lateral angles are farther from the medio-ventral angle, and the cross-section appears more triangular. The siphuncle is located about halfway between the center of the conch and its ventral side. Its structure, however, appears very different. According to one of the figures accompanying the original description of this species, the septal necks extend down-

ward for almost half the height of the camerae, while the outward curving connecting ring occupies half or three-fifths of the lower part of each camera. Barrande figures a similar structure (loc. cit., 1868, pl. 254). The siphuncle is occupied by converging vertical lamellae. From Ferrones, Asturias, Spain: in the Lower Devonian.

From typical *Jovellania*, *Mixosiphonoceras* is distinguished by the absence of annulations on the surface of the shell, by its more triangular cross-section, and by the slight rise of the sutures of the septa at each of the three angles of the conch.

The peculiar structure of the siphuncle of *Orthoceratites Jovellani* suggests that it may be generically distinct from *Mixosiphonoceras desolatum* and *Mixosiphonoceras infelix*.

4. **Tripleuroceras** Hyatt

Plate XXXII, figs. 4 A–D: plate XXXIII, figs. 2 A,B: 3 A–C

Genotype: *Orthoceras Archiaci* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, 1874, p. 102; Suppl., 1877, p. 63; pls. 251, 480. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 289.

Conch straight, cross-section depressed, ventral side distinctly flattened, dorsal side almost semicircular, with the ventro-lateral angles more narrowly rounded than any other part of the section. Sutures of the septa curving upward along the dorsal side of the conch. Siphuncle relatively large and almost in direct contact with the ventral wall. Its segments are cylindroid in outline and only moderately contracted at the septal necks. Its interior is occupied by converging vertical lamellae. From Hlubocep, Bohemia; in the lower half of the Middle Devonian, at Barrande's horizon g3. Plate XXXII, figs. 4 A–D.

Orthoceras victor Barrande (loc. cit., p. 104, pl. 353), from the same locality and horizon, is a straight, evenly enlarging conch, strongly flattened ventrally, and nearly semicircular dorsally. Compared with *Tripleuroceras archiaci*, the ventro-lateral angles are more narrowly rounded; the siphuncle is smaller, and farther from the ventral wall. Converging vertical lamellae are pres-

ent in its interior. The sutures of the septa appear directly transverse.

Orthoceratites triangularis d'Archiac and de Verneuil (Trans. Geol. Soc. London, ser. 2, vol. 6, 1842, p. 347, pl. 27, figs. 1, 1a; see also pl. XXXIII, figs. 2 A, B of this bulletin) is a straight, very slowly enlarging conch, with a depressed, sub-triangular cross-section. The ventral side is flat, and the two dorso-lateral faces are sufficiently flattened to produce an angular medio-dorsal outline. The sutures of the septa curve downward dorso-laterally and rise medio-dorsally. The siphuncle is located close to the ventral wall of the conch. Neither the description nor the figures of the type specimen give any indication of the presence of converging vertical lamellae. The faint striae which cross the surface of the cast of the interior of the conch evidently correspond to striae on the surface of the shell. These curve strongly downward along the median part of the dorsal side of the conch, with a V-shaped angulation, highly suggestive of a hyponomic sinus. According to the original description, these transverse striae curve downward also along the flattened ventral side of the conch, but without any angularity along its median line. Moreover, at the base of the living chamber the dorso-lateral walls are strongly incurved. This suggests the possibility of the aperture not being simple in outline. Possibly the side here called dorsal should be regarded as ventral, but, as far as known, the siphuncle of all the genera regarded as related is ventral in location, and, by analogy, a similar location is assumed in the present species. From Wissenbach, Germany; in the lower half of the Middle Devonian.

Orthoceras triangulare Sandberger (Versteinerungen des Rheinischen Schichtensystems in Nassau, 1850–56, p. 155, pl. 16, figs. 1–4) presents a relatively longer dorso-ventral diameter than the type of this species, though all of the specimens figured are distinctly depressed. Moreover, the siphuncle, at its passage through the septa, is in actual contact with the ventral wall of the conch, its interior being occupied by converging vertical lamellae. The sutures of the septa curve downward ventrally as well as dorso-laterally. The transverse striae curve strongly

downward both ventrally and dorsally, showing high lateral crests. In addition there are several transverse wrinkles parallel to the downward curving striae on the dorsal side of the conch and spaced at rhythmic intervals. As in the type specimen, the dorso-lateral walls of the lower part of the living chamber are strongly incurved, resulting in a dorsal keel. From Wissenbach, Germany; in the lower half of the Middle Devonian.

Orthoceras triangulare Roemer (Beiträge zur geologischen Kenntniss des nordwestlichen Harzgebirges, 1850, pt. 1, p. 64, pl. 10, figs. 6 a, b), presents a cross-section similar to that of *Tripleuroceras archiaci*, but the conch is less depressed dorso-ventrally, the ventral side is more convex, and the siphuncle, at its passage through the septum, is about two-thirds as wide laterally as dorso-ventrally. No indication of converging vertical lamellae is presented by the accompanying figures. From Büchenberg, near Elbingerode, Germany, in the Lower Devonian. Apparently this specimen represents a species distinct from *Tripleuroceras triangulare*.

Tripleuroceras (?) *roemeri* Nom. nov. (*Orthoceras triangulare* Roemer, loc. cit., 1850, pt. 5, p. 4, pl. 1, figs. 2a, b, c; see also pl. XXXIII, figs. 3 A, B, C of this bulletin) is a straight, slowly enlarging conch with a depressed triangular cross-section. The ventral and dorso-lateral sides are figured as flat, the intermediate angles being rather narrowly rounded. The siphuncle is in contact with the ventral wall of the conch, and its interior is occupied by converging vertical lamellae. The dorsal side is marked by ribs which slope obliquely downward along its ventro-lateral sides toward the median part of this dorsal side, and which occur at rhythmic intervals. The specimen is figured as having its ventral side ribbed and fluted vertically in a manner very similar to that of *Kionoceras*, a form of ornamentation unknown in any other orthoconic triangular cephalopod. This structure is almost too bizarre to be true. From the vicinity of Gosslar, Germany; in the Middle Devonian.

Tripleuroceras robsoni Whiteaves (Geol. Surv. Canada, Pal. Foss., vol. 3, pt. 4, 1906, p. 281, pls. 31, 32) from the Niagaran or Middle Silurian at Stonewall, Manitoba, is not a typical

Tripleuroceras, but probably belongs to a distinct genus. It differs in the much larger size of its siphuncle and in the absence of converging vertical lamellae. The absence of these lamellae is indicated by the presence, within the siphuncle, of an orthoceroid fully half an inch in diameter, the diameter of the siphuncle exceeding one inch. Our present knowledge of the siphuncle is inadequate for definite generic diagnosis of this new genus.

5. **Allumettoceras** Gen. nov.

Genotype: *Tripteroceras pauquettense* Foerste, Bull. Denison Univ., vol. 20, 1924, p. 233, pl. 31, figs. 2 A–D (not figs. 3 A–D which illustrate *Tripteroceras hastatum* Billings.)

Cross-section of conch differing from that of *Tripteroceras* in being less triangular; the lateral sides are more broadly rounded and the median part of the dorsal side shows no tendency toward angularity. The siphuncle is considerably larger, and is nummuloidal in vertical outline, the passage of the siphuncle through the septa being strongly contracted, while the top and bottom of the individual segments is adnate for most of their width to the adjacent septa. In other respects the general appearance of the conch is considerably like that of typical *Tripteroceras*. From Paquette Rapids, on the Ottawa River, 75 miles northwest of Ottawa, Canada; in the Black River.

Orthoceras tener Billings from the Black River of Paquette Rapids, and *Cyrtoceras planodorsatum* from the Black River of Wisconsin are congeneric.

6. **Tripteroceras** Hyatt

Genotype: *Orthoceras hastatum* Billings, Geol. Surv. Canada, Rep. of Progress for 1853–56, published in 1857, p. 333. See also Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 287; Foerste, Bull. Denison Univ., vol. 20, 1924, p. 231, pl. 31, figs. 3 A–D (not figs. 2 A–D which illustrate *Allumettoceras pauquettense* Foerste.)

Conch depressed triangular in cross-section, with ventral side flattened, and with the median part of the dorsal side broadly angular. The lateral angles of the cross-section are rather nar-

rowly rounded or obscurely truncated. The siphuncle is relatively small, and is located near the ventral side of the conch, but is not in contact with the latter. Its segments are cylindroid in vertical outline. From Pauquette Rapids, on the Ottawa River, 75 miles northwest of Ottawa, Canada.

Orthoceras xiphias Billings from the Richmond of Anticosti, *Orthoceras planoconvexum* Hall from the Trenton of Minnesota, and *Tripteroceras oweni* Clarke from the Black River of Minnesota are congeneric. *Orthoceras servile* Billings, from the Chazyan of Newfoundland, is a crushed orthoceroid not related to *Tripteroceras*.

7. **Murrayoceras** Gen. nov.

Genotype: *Orthoceras murrayi* Billings, Geol. Surv. Canada Rep. Progress for 1853–56, published in 1857, p. 332. See also Foord, Catalogue of Foss. Ceph. British Museum, vol. 1, 1888, p. 328, fig. 50 A, B, C.

Conch similar to *Tripleuroceras* in form, but differing in the structure of the siphuncle, its outline being cylindrical rather than cylindroid, and its interior is not occupied by converging vertical lamellae. The cross-section is triangular, the ventral, and dorso-lateral sides being sufficiently flattened to produce this form of section. The sutures of the septa curve downward ventrally and dorso-laterally. The siphuncle is located close to the ventral wall of the conch. From St. Joseph Island, in the northwestern part of Lake Huron, in Canadian waters; in the Black River formation.

Orthoceras semiplanatum Whiteaves from Lower Fort Garry, Manitoba, probably is congeneric. Its horizon is doubtfully referred to the Black River.

8. **Lambeoceras** Foerste

Genotype: *Gonioceras lambi* Whiteaves, Trans. Royal Soc. Canada, vol. 9, sec. 4, 1891, p. 86, pl. 11, figs. 1 A, B.

Conch greatly compressed dorso-ventrally, with the cross-section lenticular, rather strongly angular laterally, with the

siphuncle located close to the ventral wall of the conch. The segments of this siphuncle are strongly nummuloidal and are greatly contracted at the passage of the siphuncle through the septa. The septal necks are short but curve distinctly downward. The lower surface of the segments of the siphuncle is adnate to the septum immediately beneath. From East Selkirk, Manitoba, from strata doubtfully referred to the Black River.

Tripteroceras (*Lambeoceras*) *richmondense* Foerste, from the Richmond at Richmond, Indiana, is congeneric. Journ. Cincinnati Soc. Nat. Hist., vol. XXII, 1917, p. 44, pl. 1, figs. 3 A–D; pl. 3, fig. 2.

9. **Projovellania** Hyatt

Plate XXXIII, figs. 1 A–C

Genotype: *Cyrtoceras athleta* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 116, pl. 510. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 529.

Conch moderately compressed laterally along the phragmacone, more strongly compressed along the living chamber. The type specimen was broken across immediately below the living chamber but evidently was not correctly restored, since its ventral parts are not in alignment. When correctly restored this ventral outline must have been essentially straight. Under these circumstances it is probable that the dorsal outline also was either straight or nearly so. In other words, if this conch ever was curved lengthwise, this curvature must have been slight. The living chamber is marked by transverse wrinkles of growth which rise slightly ventro-laterally and curve distinctly downward along the median part of the ventral side, thus locating the hyponomic sinus. The direction of the transverse lines on the living chamber is not in agreement with those on the phragmacone. The latter curve downward along the median part of the lateral sides, and are not known to curve downward along the median part of ventral side, as in the case of the associated living chamber. Hence, the phragmacone here is selected as the type of the species and also as the type of the genus. The

sutures of the septa are almost directly transverse and straight. The siphuncle is located close to the ventral wall of the conch. The structure of the siphuncle is not indicated clearly in Barrande's figure. Apparently there were relatively long septal necks connected by convex connecting rings, resulting in a somewhat nummuloidal siphuncle, but the latter was not strongly constricted at the septal necks, and to this extent has a broadly cylindroid, rather than typically nummuloidal outline. No trace of converging vertical lamellae is present. From Dvoretz, Bohemia; in the Middle Silurian, at Barrande's horizon e2. Plate XXXIII, figs. 1 A–C.

Cyrtoceras solitarium Barrande (loc. cit., 1867, p. 620, pl. 155) from the same locality and horizon as the preceding, may belong to a different relationship. The fragment presents a more cyrtoceroid appearance, and is more compressed laterally. The segments of its siphuncle are cylindroid in outline, and their interior is occupied by converging vertical lamellae.

Projovellania differs from *Jovellania*, *Mixosiphonoceras*, and *Tripleuroceras* in the lateral compression of its conch, the conch of the other genera named being depressed dorso-ventrally. In *Jovellania* this dorso-ventral depression is slight, and the longitudinal angulation of the conch along its ventral side is due to a slight flattening of its ventro-lateral sides. In *Mixosiphonoceras* and *Tripleuroceras* the cross-section of the conch tends to be triangular. In the former genus the median part of the ventral side tends to be angulate; in the latter genus it is the median part of the dorsal side which is more angulate.

II. COMPRESSED BREVICONIC CYRTOCERACONES

In the Rizoceratidae Hyatt included two genera, *Rizoceras* and *Cyrtorizoceras*. Of these, *Rizoceras* appears to have originated from a cyrtoceraconic stock which retained its lengthwise curvature only in its initial stages of growth, becoming orthoconic at all later stages. *Cyrtorizoceras*, on the contrary, appears to have been similar to that early Ordovician stock which gave rise to the Oncoceratidae. Its living chamber narrows laterally near the aperature, but not dorso-ventrally.

In the Oncoceratidae Hyatt included *Eremoceras, Cyclostomiceras, Oncoceras,* and *Maelonoceras.* Of these, *Eremoceras* and *Cyclostomiceras* are regarded as Holochoanites (Denison Univ. Bull., vol. 21, 1925, p. 12). This leaves *Oncoceras* and *Maelonoceras,* to which may be added *Cyrtorizoceras,* and *Beloitoceras.* All of these genera have siphuncles located near the convex ventral side of the conch, their segments being narrowly fusiform in outline, and their interior being free from converging vertical lamellae. In *Cyrtorizoceras* the aperture is contracted only laterally. In *Maelonoceras* the aperture is contracted to a pyriform outline, the narrower part being ventral. In *Beloitoceras* the contraction of the aperture is distinctly less, being more or less oviform, with the narrower side ventral; and in typical forms the dorsal side of the living chamber tends to be slightly gibbous. In *Oncoceras* the dorsal side of the conch is distinctly gibbous at the base of the living chamber and the top of the phragacone, and this is the most gibbous part of the conch also ventrally. *Karoceras* may be a late representative of this group, but the interior of its siphuncle is occupied by converging vertical lamellae.

In *Wissenbachia* the conch reaches its maximum gibbosity laterally and ventrally at the base of the living chamber and the top of the phragmacone, but the dorsal side of the conch presents a concave vertical outline. The siphuncle is located close to the ventral side of the conch; its segments are cylindroid, and its interior is occupied by converging vertical lamellae.

10. **Rizoceras** Hyatt

Plate XXXIV, figs. 3 A–E

Genotype: *Orthoceras indocile* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, 1874, p. 57, pl. 185. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 276.

Conch breviconic, nearly straight except at its apical end, where the ventral outline is slightly convex and the dorsal outline is slightly concave. The transverse striae on the surface of the shell curve downward both dorsally and ventrally, but

the downward curvature along the dorsal side extends across the entire width of the conch, while that along the ventral side is confined to the median part of this side and here is regarded as locating the hyponomic sinus, thus identifying the ventral side of the conch. The conch is compressed laterally. The sutures of the septa are directly transverse. The siphuncle is located near the ventral wall of the conch. Its segments are somewhat fusiform in outline, enlarging toward their tops. They contract at the septal necks to less than half of their maximum diameter within the camerae. No converging vertical lamellae are present. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon e2.

11. **Cyrtorizoceras** Hyatt

Plate XXXV, figs. 3 A–C

Genotype: *Cyrtoceras minneapolis* Clarke, Geol. Minnesota, vol. 3, pt. 2, 1897, p. 808, pl. 59, figs. 1–6. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 529.

Conch a breviconic cyrtoceracone, strongly compressed laterally, with siphuncle near the convex ventral side of the conch. The conch enlarges dorso-ventrally as far as the aperture. At gerontic stages of growth the upper part of the living chamber, for a length of 4 mm. from the aperture, may be slightly contracted laterally. The cross-section of the conch is more narrowly rounded ventrally than dorsally. The dorsal vertical outline of the conch is concave along its entire length, and there is no faint gibbosity along the dorsal outline of the living chamber as in typical *Beloitoceras*.[22] The transverse striae on the surface of the shell curve downward both dorsally and ventrally, but along the median part of the ventral side this downward curvature is deeper and more abrupt, thus locating the hyponomic sinus, and identifying the ventral side of the conch. The sutures of the septa curve slightly downward laterally. The siphuncle is close to the ventral wall of the conch, the basal parts of its

[22] *Beloitoceras* Foerste, Bull. Denison Univ. Lab., vol. 20, 244-253; (1924).

segments frequently being in actual contact. These segments are narrowly fusiform in outline, and are strongly constricted at the septal necks. No trace of converging vertical lamellae is present. From Minneapolis, Minnesota; in the Platteville member of the Black River formation, in the Middle Ordovician.

12. **Maelonoceras** Hyatt

Genotype: *Phragmoceras praematurum* Billings, Canadian Naturalist, vol. 5, 1860, p. 163, figs. 20. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 280; Foerste, Bull. Denison Univ., vol. 20, 1924, pl. 242, pl. 39, figs. 6 A, B, C, pl. 41, fig. 7.

Conch similar to *Cyrtorizoceras* along the phragmacone and the lower part of the living chamber, but contracting at the aperture so as to leave a more or less pear-shaped orifice. The dorsal outline of the conch is concave even along the living chamber. Toward the aperture, the ventral outline of the living chamber curves more strongly inward, shortening the dorso-ventral diameter. The ventro-lateral margins of the aperture rise into low crests which curve inward, thus producing the pear-shaped outline of the aperture. The pronounced development of this form of aperture is the chief characteristic of the genus. No converging vertical lamellae are present within the siphuncle. From LaCloche Island, in the northern part of Lake Huron, Ontario, Canada, in the Black River formation, in the Middle Ordovician.

Maelonoceras billingsi Foerste (Bull. Denison Univ. 20, 1924, p. 244, pl. 39, figs. 5 A, B, C), from the same locality and horizon, is founded on the living chamber of a straighter conch in which the generic characteristics of the aperture are shown even more strikingly than in *Maelonoceras praematurum*.

13. **Beloitoceras** Foerste

Genotype: *Oncoceras pandion* Hall. See Whitfield, Mem. Amer. Mus. Nat. Hist., vol. 1, pt. 2, 1895, p. 69, pl. 9, figs. 21, 22; also Foerste, Bull. Denison Univ., vol. 20, 1924, p. 244, pl. 36, figs. 5 A, B; pl. 41, figs. 4 A, B, C.

Conch similar to the ancestral stage of *Maelonoceras*, but with aperture slightly oval rather than pyriform in outline, and there is a tendency toward faint gibbosity along the dorsal outline of the living chamber. In typical *Oncoceras* this gibbosity is much more pronounced both dorso-ventrally and laterally, but the chief distinction of the latter genus is the location of its gibbosity at the base of the living chamber and the top of the phragmacone.

The genotype, *Oncoceras pandion*, is from Beloit, Wisconsin; in the Black River formation.

14. **Oncoceras** Hall

Genotype: *Oncoceras constrictum* Hall, Pal. New York, vol. 1, 1847, p. 197, pl. 41, figs. 6 A–F, 7 A–D. See also Foerste, Bull. Denison Univ., vol. 20, 1924, p. 239, pl. 39, figs. 2, 3, 4.

Laterally compressed breviconic cyrtoceracones, gibbous both laterally and dorso-ventrally at the base of the living chamber and the top of the phragmacone. At this level the convex curvature of the ventral outline tends to increase and the concave outline of the dorsal side of the conch reverses to a convex outline. The margin of the aperture curves down ventrally, forming an angular, relatively narrow hyponomic sinus. The sutures of the septa curve slightly downward laterally. The siphuncle is close to the ventral wall of the conch. Its segments vary between elongate elliptical and narrowly fusiform in outline, as in *Beloitoceras* and *Cytorizoceras*. No converging vertical lamellae are present. From Middleville, New York, in the Trenton formation, Middle Ordovician.

15. **Karoceras** Roussanoff

Plate XXXV, figs. 2 A–F

Genotype: *Karoceras typicum* Foerste (incorrectly identified by Roussanoff with *Cyrtoceras laminare* Barrande). See Foerste, Cephalopoda from Nesnayemi and Sulmeneva Fjords in Novaya Zemblya, in Report of the Scientific Results of the Norwegian Expedition to Novaya Zemblya in 1921, No. 31, 1925, pp. 18, 19, pls. 3, 6, 7.

Conch similar to that of *Cyrtorizoceras*, but the sutures of the septa rise much more strongly ventrally, especially toward the upper part of the phragmacone, and the interior of the siphuncle is occupied by converging vertical lamellae. As in *Cyrtorizoceras*, the conch is breviconic, strongly compressed laterally, the sides converging more or less distinctly toward the convex ventral side of the conch. Sutures of the septa with shallow vertical lobes. At earlier stages of growth the ventral saddles rise to about the same height as the dorsal ones, but later the sutures rise more and more strongly ventrally, until at mature stages of growth they form angles of about 45 degrees with the curving longitudinal axis of the conch. The segments of the siphuncle are obliquely oval or elongate elliptical in outline, varying in some forms to scalariform or step-like dorso-ventral outlines. The transverse striae on the surface of the shell curve increasingly downward ventrally, locating the former presence of the hyponomic sinus. From Nesnayemi Fjord, on Novaya Zemblya; in strata provisionally regarded as of Lower Devonian age.

Unfortunately, nothing is known of the character of the aperture of *Karoceras*.

16. **Wissenbachia** Gen. nov.

Plate XLIV, figs. 1 A–C

Genotype: *Phragmoceras orthogaster* Sandberger, Versteinerungen des Rheinischen Schichtensystems in Nassau, 1850–56, p. 150, pl. 14, figs. 4, 4 A, 4 B.

Conch breviconic, cyrtoceroid; slightly concave, almost straight, dorsally; more strongly convex along its ventral side, with the greatest gibbosity at the top of the phragmacone. Moderately compressed laterally, especially toward the aperture and the lower end of the specimen; slightly more narrowly rounded along the ventral side. Sutures of the septa straight. Siphuncle located close to the ventral side of the conch; its segments slightly inflated within the camerae; its interior occupied by converging vertical lamellae. Surface of the shell

nearly smooth, with very faint vertical and horizontal intersecting lines. From Wissenbach, Germany, in the Middle Devonian. Plate XLIV, figs. 1 A–C.

Cyrtoceras sanum Barrande (Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 564, pl. 145), presents a somewhat similar dorsal and ventral outline, but the point of maximum ventral gibbosity of the conch is above the base of the living chamber, and the suture at the base of this chamber slopes more strongly downward ventrally. Moreover, its siphuncle appears narrower, and its interior does not contain converging vertical lamellae.

III. COMPRESSED LONGICONIC CYRTOCERACONES

Hyatt included in the Ooceratidae the two genera *Oonoceras* and *Cyrtoceras,* of which the first is compressed laterally, and the second is depressed dorso-ventrally. Of these only *Oonoceras* here is retained, and to this genus are added provisionally the compressed longiconic genera *Oocerina* and *Perimecoceras.* In *Oonoceras* the segments of the siphuncle are cylindroid, and no converging vertical lamellae are known. In *Oocerina* these segments are nummuloidal in form, and converging vertical lamellae are present. In *Perimecoceras* the vertical outlines of the segments of the siphuncle are concave, instead of convex. A similar structure is shown by the segments of *Blakeoceras,* but the shell is more breviconic. Both *Perimecoceras* and *Blakeoceras* have converging vertical lamellae, as in *Oocerina.*

17. **Oonoceras** Hyatt

Plate XXXIV, figs. 1 A–D

Genotype: *Cyrtoceras acinaces* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 476, pls. 118, 124. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 280.

Conch a longiconic cyrtoceroid, strongly compressed laterally, moderately curved lengthwise, with the siphuncle located near the convex ventral side of the conch. The rate of enlargement of the conch is very slow. The living chamber is relatively short

and it is not contracted toward the aperture. The walls of this chamber, however, are thickened by a calcareous deposit lining its interior so that casts of the interior appear constricted at about one-third of the height of this chamber from the aperture. The surface of the shell is distinctly annulated, the annulations curving downward ventrally, and forming an angulation along the median line of the ventral side which evidently locates former positions of the hyponomic sinus, thus identifying the ventral side of the conch. The sutures of the septa curve only slightly downward laterally. The segments of the siphuncle are narrowly cylindroid in outline. No converging vertical lamellae are present. The shell is thick, and the annulations are confined to its surface, the cast of the interior of the conch being smooth. From Dlauha-Hora, Bohemia; in the Middle Silurian, at Barrande's horizon e2.

18. **Oocerina** Gen. nov.

Plate XXXIV, figs. 2 A–D

Genotype: *Cyrtoceras lentigradum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 599, pl. 137.

Conch closely similar to that of *Oonoceras* in form, but differing strongly in the structure of its siphuncle. The segments of the latter are distinctly nummuloidal, broader than high, and strongly contracted at the septal necks. Moreover, their interior is occupied by converging vertical lamellae, which rise from the level of the septal necks for two-thirds of the height of the segments within which they occur. The outline of the aperture apparently was straight, without a distinct hyponomic sinus. From Lochkov, Bohemia; in the Middle Silurian, at Barrande's horizon E. Plate XXXIV, figs. 2 A–D.

Cyrtoceras stygiale Barrande (loc. cit., Suppl., 1877, p. 15, pl. 480) has broadly heart-shaped segments of the siphuncle, and the latter contains converging vertical lamellae. From Dvoretz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

Cyrtoceras strangulatum Barrande (loc. cit., p. 184, pl. 512)

has nummuloidal segments which apparently enlarge somewhat toward their lower ends, in a manner similar to *Cyrtoceras abditum*. The interior of these segments is occupied by converging vertical lamellae. The transverse lines of growth indicate the presence of a distinct hyponomic sinus along the convex ventral side of the conch, which suggests the possibility of this species being distinct generically from *Oocerina lentigradum*. From Dvoretz, Bohemia, in the Middle Silurian, at Barrande's horizon e2.

Cyrtoceras abditum Barrande (loc. cit., Suppl., 1877, p. 15, pl. 480) also has segments of the siphuncle which enlarge toward their bases, thus presenting a somewhat truncate conical outline. Their interior is occupied by converging vertical lamellae. From Slivenetz valley, Bohemia; in the Middle Silurian, at Barrande's horizon e2.

19. **Perimecoceras** Gen. nov.

Plate LII, figs. 2 A–C

Genotype: *Cyrtoceras contrastans* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 129, pl. 500.

Conch similar in general aspect to *Oonoceras* and *Oocerina*, but with a much longer living chamber, and with the segments of the siphuncle presenting concave vertical outlines. The interior of the siphuncle contains converging vertical lamellae. From the Slivenetz valley, Bohemia; in the Middle Silurian, at Barrande's horizon e2.

20. **Blakeoceras** Gen. nov.

Plate LII, figs. 3 A–C; plate LI, figs. 4 A, B

Genotype: *Cyrtoceras empiricum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 141, pl. 541.

Conch similar to *Perimecoceras* to the extent that it is curved lengthwise, laterally compressed, and with the siphuncle along the convex ventral side of the conch; but the rate of enlargement of the phragmacone is greater, the living chamber is relatively shorter and the diameter of its siphuncle is larger when

compared with the dorso-ventral diameter of the conch. The downward curvature of the sutures of the septa is slight. The segments of the siphuncle present concave vertical outlines, and their interior is occupied by converging vertical lamellae. Apparently the latter are discontinuous. From Hlubocep, Bohemia in the Middle Devonian, at Barrande's horizon g3. Plate LII, figs. 3 A–C.

Cyrtoceras Llandoveri Blake (British Fossil Cephalopoda, 1882, p. 171, pl. 21, figs. 1, 1A) resembles *Blakeoceras empiricum* as far as the British species is known. The latter is founded on a phragmacone, with the siphuncle a short distance from the ventral wall. Its segments present concave vertical outlines, and the inner surface of the wall of the siphuncle is marked by vertical lines which suggest the former presence of converging vertical lamellae. From Craig-yr-Wyddon, Great Britain; in the Lower Llandovery member near the base of the Middle Silurian. Plate LI, figs. 4 A, B.

IV. CIRCULAR BREVICONIC CYRTOCERACONES

Wetherbyoceras is nearly circular in outline. Occasionally the cross-section of the conch appears slightly more narrowly rounded ventrally, and in those cases the dorso-ventral diameter is slightly greater than the ventral one. The segments of the siphuncle are globular in form, and converging vertical lamellae are present.

21. **Wetherbyoceras** Gen. nov.

Plate XLIII, fig. 4

Genotype: *Cyrtoceras conoidale* Wetherby. Journ. Cincinnati Soc. Nat. Hist., vol. 4, 1881, p. 78, pl. 2, fig. 6 A.

As genotype of *Wetherbyoceras*, specimen No. 35064 in the U. S. National Museum has been selected. This specimen is identified provisionally as *Cyrtoceras conoidale*, on account of its moderate lengthwise curvature, although its rate of enlargement is much less than that of the type of *Cyrtoceras conoidale* as figured by Wetherby.

Conch a breviconic cyrtoceroid, circular in cross-section, with the siphuncle located close to its ventral side. The lateral diameter enlarges from 7 to 17 mm. in a length of 17 mm. Eight camerae occur in a length equal to the diameter of the conch at the top of the series of camerae counted. The sutures of the septa rise slightly toward the ventral side along the upper part of the specimen. Septa only slightly concave. Siphuncle near, but not in actual contact with the ventral wall of the conch. Its segments are obliquely globular in outline, and are strongly constricted at the septal necks. Cross-sections of the siphuncle expose 10 to 12 converging vertical lamellae. From Point Leavel, Garrard County, Kentucky; in the Leipers member of the Maysville formation, in the Upper Ordovician.

In some silicified specimens from central Kentucky the dorso-ventral diameter is slightly greater than the lateral one, and the ventral side is slightly more narrowly rounded than the dorsal one. These specimens are from McKinney, Lincoln County, Kentucky, and are numbered 48337 in the U. S. National Museum. They also are from the Leipers member of the Maysville.

Closely similar specimens, which at present can not be differentiated from those forms of *Wetherbyoceras conoidale* here described, occur in the lower or Economy member of the Eden formation, in the Upper Ordovician. The Eden formation occurs directly beneath the Maysville. There are two of these specimens, both nearly circular in cross-section, and with rates of enlargement fully equalling that of the figured type of *Wetherbyoceras conoidale*. The one numbered 48333 in the U. S. National Museum is labelled as coming from 75 feet above low water mark in the Ohio River, at West Covington, Kentucky, the base of the Eden here being 50 feet above low water. The top of this specimen contains an excellent impression of the cephalon of *Cryptolithus*, and its base presents a cross-section of the siphuncle with distinct converging vertical lamellae. The second specimen, numbered 48334 in the same museum, is labelled as coming from the 110 foot level near Newport, Kentucky. Both specimens evidently belong to the genus *Wetherbyoceras*, but both are too short to determine with exact-

ness the rate of enlargement and of lengthwise curvature of the conch, and hence it can not be learned at present whether these specimens are to be regarded as identical with *Wetherbyoceras conoidale*, or merely as closely related.

V. ERECT BREVICONES WITH MODERATELY CONSTRICTED APERTURES

The term Diestoceratidae is proposed for relatively short conchs which contract along the living chamber toward the aperture; this aperture, however, remains open, without any differentiation into dorsal and ventral lobes. The type genus is *Diestoceras*, in which the hyponomic sinus is indicated by a slight downward curvature of the ventral margin of the aperture, the outline of the latter being slightly more narrowly rounded here. In the species *Diestoceras scalare*, from Anticosti, the structure of the siphuncle is scalariform, apparently with a slightly concave outline along the dorsal side of its segments, and short converging vertical lamellae are present at the septal necks. This species may be distinct from typical *Diestoceras* in which no converging vertical lamellae are known. In *Pictetoceras* the conch is strongly compressed laterally, the sutures of the septa curve slightly downward laterally, and the siphuncle is in contact with the ventral wall of the conch. According to the original description of its genotype, the segments of the siphuncle apparently present concave vertical outlines, but this needs verification. In *Herkimeroceras* the conch is erect, but there is a faint suggestion of gibbosity of the dorsal outline at the top of the phragmacone and base of the living chamber, as in *Poterioceras*. In *Pachtoceras*, the siphuncle is located halfway between the center of the conch and its ventral wall. The segments of the siphuncle are cylindroid, and the lower halves of their interiors are lined with vertical narrow ridges, corresponding to the vertical converging lamellae of other genera. In the preceding genera the conchs are distinctly compressed laterally.

In *Sycoceras* the cross-section of the conch is virtually circular, but the location of the siphuncle is marginal, and the

living chamber contracts upward, the aperture being circular, as far as known.

22. **Diestoceras** Foerste

Genotype: *Gomphoceras indianense* Miller and Faber. Jour. Cincinnati Soc. Nat. Hist., vol. 17, 1894, p. 137, pl. 7, figs. 3–5. See also Foerste, Bull. Denison Univ., vol. 20, 1924, p. 262, pls. 25–28.

Erect conchs with a vertical outline resembling that of typical *Gomphoceras,* but with the aperture only slightly contracted, the hyponomic sinus being indicated by a very moderate downward curvature of the ventral margin of this aperture. The outline of the aperture is elliptical, elongated moderately dorsoventrally, and slightly more narrowly rounded ventrally. The siphuncle is located near the ventral wall of the conch. Its structure appears to vary in different specimens from scalariform to nummuloidal. Evidently further study is necessary in order to get a clear idea of the structure of the siphuncle of typical *Diestoceras.*

The genotype, *Diestoceras indianense,* was found in the Richmond at Versailles, Indiana. The species is relatively abundant in the lower part of the Whitewater member of the Richmond near Oxford, Ohio.

22A. **"Diestoceras" scalare** Foerste

Plate LII, fig. 1

Conch erect, obese, reaching its maximum diameter about two-fifths of the height of the living chamber above its base, and then contracting moderately toward the aperture. In general outline this conch probably resembled *Diestoceras* (Foerste, Denison Univ. Bull., vol. 20, 1924, p. 262, pls. 25, 26, 27, 28), but the structure of its siphuncle appears to have been different. This structure may be described as scalariform. Along that side of the siphuncle which faces the interior of the conch, the vertical outline of its segments is slightly concave, especially toward the base of the segments, while along the opposite side

of the segments their vertical outline is nearly straight in general, but more or less convex toward the top. The interior of the siphuncle contains converging vertical lamellae, which appear to start at the level of the septal necks and to extend thence upward and downward. From West-end Light-house, Anticosti; in the Charleston member of the Richmond formation. Specimen No. 2211, Geological Survey of Canada.

23. **Pictetoceras** Gen. nov.

Plate XLIV, fig. 4

Genotype: *Gomphoceras Eichwaldi* Verneuil, Geologie de la Russie D'Europe et de Montagnes de l'Oural, vol. 2, Paleontologie, 1845, p. 357, pl. 24, fig. 9. See also Pictet, Traite de Paleontologie, 1854, p. 645.

Conch enlarging as far as the upper part of the phragmacone and then contracting toward the aperture. Cross-section compressed laterally. Living chamber relatively high, but nothing is known of its aperture. The sutures of the septa rise distinctly toward the median part of the ventral side of the conch. The siphuncle is located close to the ventral side of the conch. Regarding the siphuncle, de Verneuil stated that "ce siphon présente une grande analogie avec celui de l'*O. piriformis* Murch., dont il diffère toute-fois en ce que les étranglements correspondent au milieu de l'espace intercloisonnaire, et non à la cloison même." This statement suggests the possibility of this species belonging to the group here described in which the vertical outlines of the segments of the siphuncle are concave, instead of convex. No converging vertical lamellae are present in this species. From St. Petersburg, Russia; in the Ordovician.

24. **Herkimeroceras** Gen. nov.

Plate LI, figs. 2 A–C

Genotype: *Cyrtoceras subrectum* (Hall). Pal. New York, vol. 3, 1859, pl. 69, figs. 3 A–D.

Conch nearly straight, with the dorsal outline essentially

straight, while the ventral outline is distinctly, though only slightly, curved. Possibly the lower part of the dorsal outline is faintly concave, and the upper part of this outline is faintly gibbous. The conch is slightly compressed laterally. The sutures of the septa are straight, but rise slightly ventrally. The siphuncle is almost in contact with the ventral wall of the conch, especially along the lower margin of the segments. The general outline of the segments appears nummuloidal in one specimen and scalariform or step-like in another. The septal necks are short. The interior of the siphuncle was occupied by radiating vertical lamellae not reaching its center. From Litchfield, Herkimer County, New York; in the Keyser member at the base of the Lower Devonian.

25. **Pachtoceras** Gen. nov.

Plate XLIV, figs. 2 A–C

Genotype: *Gomphoceras rotundum* Pacht, Helmersen and Pacht, Beiträge zur Kenntniss des Russischen Reiches, 1858, vol. 21, p. 84, pl. 2, figs. 2, 2 A.

Fragment consisting of a living chamber with two camerae still attached. This living chamber contracts toward the aperture, and, as far as known, the latter is approximately circular, nothing definite being known of its outline. The conch is slightly compressed laterally. The siphuncle is located about half-way between the center of the conch and its ventral side. Its segments are elongate elliptical or cylindroid in outline, and the lower half of their interior is occupied by radiating vertical lamellae. From Gräsi, on the Matyra River, in the Upper Don area of Russia; in the Upper Devonian. Plate XLIV, figs. 2 A–C.

Gomphoceras sulcatulum de Verneuil (Geol. de la Russie, Murchison, Verneuil, and Keyserling, pt. 2, 1845, p. 357, pl. 25, fig. 6) presents a similar living chamber, as far as its general outline is concerned, but nothing is known of its siphuncle, not even its location. From the vicinity of Voroneje, near the Don, in Russia; in the Upper Devonian.

26. Sycoceras Pictet

Plate XLIV, figs. 5 A, B

Genotype: *Gomphoceras ficus* Roemer, Paleontographica, vol. 3, 1854, p. 38, pl. 6, figs. 1 A, B; Pictet, Traite de Paleontologie, Atlas, 1854, pl. 51, fig. 11.

Conch gomphoceroid in outline, enlarging as far as the base of the living chamber, and then contracting toward the aperture. The cross-section of the conch at the base of the specimen figured is circular, and, as far as known, this circular outline continues as far as the aperture. The siphuncle is small, and is located close to the ventral wall of the conch. In the genotype the surface of the shell is crossed by low, broad, raised lines, some of which, at rhythmical intervals, are sufficiently prominent to be called relatively low, narrow annulations. However, there is no reason for assuming that this type of ornamentation is characteristic of other species of the genus, should the latter occur. Upper Devonian of Harz area, Germany.

Pictet, under the generic term *Sycoceras*, cites *Gomphoceras Eichwaldi* Verneuil first, and *Gomphoceras ficus* Roemer second, but the second species is the only one he figures, and, therefore, the latter is selected here as the genotype. The species evidently are not congeneric, as might be expected from the fact that the one cited first is of Ordovician age, while the one cited second is of Upper Devonian age. In *Gomphoceras Eichwaldi* the conch is compressed laterally; the siphuncle is relatively large, and the sutures of the septa rise distinctly toward the median part of the ventral side of the conch.

VI. CYRTOCERACONES WITH POTERIOCERIOID OUTLINES

Hyatt included in the Poterioceratidae the genera *Clinoceras*, *Sycoceras*, *Poterioceras*, *Acleistoceras*, and *Streptoceras*. Of these *Poterioceras* is characterized by a dorsal gibbosity along the upper part of the phragmacone and the lower part of the living chamber. The living chamber contracts toward the aperture, but the outline of the latter, as far as known, is circular, or nearly

so. The siphuncle is located ventrad of the center of the conch, and its segments are approximately fusiform. *Streptoceras* presents a similar vertical outline, but the aperture is triangular, with a well-developed hyponomic sinus, and the segments of the siphuncle are barrel-shaped, and abruptly contracted at the septal necks. *Acleistoceras* also presents a triangular or T-shaped aperture, with a well-developed hyponomic sinus. *Clinoceras* begins as a typical annulosiphonate conch, the segments of the siphuncle later becoming cylindroid; there is a slight but distinct indication of a hyponomic sinus. In *Sycoceras* the conch is strictly erect, without any poterioceroid vertical outline. It is doubtful whether any of the genera *Clinoceras*, *Sycoceras*, *Acleistoceras*, or *Streptoceras* belong to the same family as *Poterioceras*. In fact, the origin of the latter at present is a mystery.

Several genera have outlines similar to those of *Poterioceras*, however without showing any relationship with the latter. In *Westonoceras* the conch reaches its maximum diameter 5 or 6 camerae beneath the top of the phragmacone, and here the dorsal outline is slightly gibbous. The living chamber narrows to a short cylindrical neck at its top. The siphuncle is located between the center of the conch and its ventral wall, and its outline is scalariform. The general outline of the conch of *Mecynoceras* is uncertain. The conch attains its maximum dorso-ventral diameter a considerable distance beneath the top of the phragmacone, and it narrows upward toward the aperture, but the remainder of its outline is unknown. Its most peculiar feature is the form of the segments of its siphuncle, which are annulated at mid-height.

27. **Poterioceras** McCoy

Plate XLVI, figs. 3, 4 A, B

Genotype: *Orthocera fusiformis* Sowerby, Min. Conch., vol. 6, 1829, p. 167, pl. 588, fig. 1 (not fig. 2). See also Foord, Monograph of Carb. Ceph. of Ireland, pt. 2, 1898, p. 43, pl. 15, figs. 1–3. Foerste, in Bull. Denison Univ., vol. 20, 1924, p. 254, pl. 40, fig. 2; pl. 41, figs. 1 A, B.

Conch a breviconic cyrtoceracone with circular cross-section, or slightly compressed laterally, with the ventral outline convex and the dorsal outline concave along the lower part of the phragmacone and the upper part of the living chamber, but convexly gibbous along the upper part of the phragmacone and the lower part of the living chamber. The living chamber is contracted toward the aperture and the outline of this aperture is slightly elliptical or circular, with no indication of a hyponomic sinus. If a trace of the latter is present, it has not been observed so far in any described species. The sutures of the septa are directly transverse along the greater part of the length of the phragmacone, but toward the living chamber these sutures rise distinctly from the ventral toward the dorsal side of the conch. The siphuncle is located a short distance ventrad of the center of the conch. According to Foord, it is marginal on the ventral side of the conch in the young, but recedes a little toward the center in the adult. Its segments present elongate elliptical outlines. No converging vertical lamellae are present. From St. Doulagh's, Dublin, Ireland; in Lower Carboniferous limestone.

28. **Westenoceras** Foerste

Genotype: *Cyrtoceras manitobense* Whiteaves. Trans. Royal Soc. Canada, vol. 7, sect. 4, 1889, p. 80, pl. 13, figs. 3, 4; pl. 15, fig. 4. See also Foerste, Bull. Denison Univ., vol. 20, 1924, p. 253.

Cyrtoceracone elongate, nearly erect, with the ventral outline distinctly, though not strongly, convex, but with the dorsal outline almost straight. Along the more apical part of the conch this dorsal outline is slightly concave, but along most of the remainder of the conch it is faintly convex, except near the aperture, where the conch curves rather abruptly in a dorsad direction. The conch is contracted toward the aperture but the latter apparently is round, and without a hyponomic sinus. The siphuncle is located between the center of the conch and its ventral margin. Its structure appears to be scalariform. From Big Island and Bull's Head, on Lake Winnipeg; either of Black River or Richmond age. Not regarded as related to

Poterioceras, though presenting a somewhat similar dorso-ventral outline.

29. **Mecynoceras** Gen. nov.

Plate XLIV, figs. 3 A–C

Genotype: *Gomphoceras rex* Pacht, in Helmersen and Pacht, Beiträge zur Kenntniss des Russischen Reiches, vol. 21, 1858, p. 78, pl. 1, figs. 1–4; also p. 74.

Conch laterally compressed, considerably elongated cyrtoceroid, of which only the living chamber and the upper part of the phragmacone is known. The upper part of the phragmacone, for a length of at least 30 mm., contracts dorso-ventrally as far as the base of the living chamber, and this contraction continues in diminishing degree along the lower half of this chamber. The right outline of this specimen, as figured, is nearly straight. Its left outline, however, is distinctly concave, the maximum concavity being near the base of the living chamber. The sutures of the septa curve downward laterally; toward the top of the phragmacone they rise slightly higher on the right side of the specimen. The location of the siphuncle is central. The form of its segments resembles that of short, broad barrels, of which the middle third is enlarged in a conspicuously annular manner. Their interior is occupied by converging vertical lamellae.

It can not be determined with confidence whether the right or the left side of the specimen, as figured, is to be regarded as ventral. If the convex curvature along the lower part of its right side is natural, then this side may be the ventral one, and the left side may be dorsal, with a tendency toward gibbosity along that part of the phragmacone which is preserved.

From Jelez, Sadonsk, and elsewhere in the northern part of the Don River area, in Russia; in the Upper Devonian.

VII. DEPRESSED POTERIOCEROIDS WITH HYPONOMIC SINUS

Amphicyrtoceras presents a poterioceroid vertical outline with a gibbous dorsal outline along the lower part of the living chamber, but the cross-section of the conch is distinctly depressed

dorso-ventrally, and there is a shallow but distinct downward curvature of the ventral outline of the aperture indicating a hyponomic sinus. The segments of the siphuncle are barrel-shaped, and abruptly contracted at the septal necks. *Streptoceras* differs only in the protuberant hyponomic sinus at the gerontic stage of development of the conch. *Monocyrtoceras* (Foerste, Denison Univ. Bull., vol. 20, 1924, p. 259) presents a similar siphuncle, but without any gibbous enlargement dorsally. These three genera are related to one another.

Poteriocerina and *Paracleistoceras* present similar poterioceroid vertical outlines, but in *Poteriocerina* the dorsal gibbosity is at the base of the living chamber, and in *Paracleistoceras* it is distinctly above this base. Moreover, in *Poteriocerina* the outline of the aperture apparently is transversely elliptical, without a hyponomic sinus, while in *Paracleistoceras* it is triangular or T-shaped, with a distinct hyponomic sinus.

Acleistoceras is similar to *Paracleistoceras* in the outline of its aperture, but the conch is strictly erect, the lengthwise vertical outlines of its dorsal and ventral sides being closely similar.

Cyrtoceras, according to the descriptions published by Hyatt, also has an aperture similar to that of *Paracleistoceras*, but the conch is strongly curved lengthwise, and no dorsal gibbosity is present.

Cyrtactinoceras begins as a slightly curved actinoceroid, with globular segments of the siphuncle, the latter becoming cylindroid in old age. The cross-section of the conch is depressed, especially along its upper part, and the ventral side of the aperture curves downward, somewhat as in *Amphicyrtoceras*, but there is no dorsal gibbosity.

30. **Amphicyrtoceras** Foerste

Plate XLVII, figs. 2 A, B; 3

Genotype: *Oncoceras orcas* Hall, 20th Rept. New York State Cab. Nat. Hist., 1868, p. 350, pl. 17, figs. 1, 2. See also Foerste, Denison Univ. Bull., vol. 20, 1924, pls. 29, 30.

Conch similar to *Poterioceras* in its dorsal and ventral vertical

outlines; however, its cross-section is distinctly depressed dorso-ventrally, especially along the living chamber and the upper part of the phragmacone, and there is a distinct, though very shallow, hyponomic sinus. The siphuncle is located near, but not in contact with, the ventral wall of the conch. The general outline of its segments is cylindrical, but abruptly and obliquely contracted at the septal necks. No converging vertical lamellae are present within the siphuncle. From Waukesha, Wisconsin; in the Racine member of the Middle Silurian.

30A. **Amphicyrtoceras** (?) **penultimum** Barrande

Cyrtoceras penultimum Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 40, pl. 470.

Conch represented only by a phragmacone which is insufficient to determine whether it had a form similar to that of *Amphicyrtoceras;* however, the structure of its siphuncle is so closely similar as to suggest the possibility of its relationship to the latter genus, though not necessarily inferring actual membership in the same. The segments of the siphuncle are constricted with similar abruptness at the septal necks, and the lateral outlines of these segments are somewhat similar, but the latter are slightly constricted at mid-height, and the upper halves of these segments are distinctly larger in diameter than their lower halves. Their interior is occupied by converging vertical lamellae. From Gros-Kuchel, Bohemia; in the Middle Silurian, at Barrande's horizon e3.

Cyrtoceras penultimum is the only European species known to the writer in which the structure of the siphuncle resembles that of *Amphicyrtoceras.* The presence of the converging vertical lamellae, and the other minor differences in the structure of the siphuncle here described, suggest the possibility of this species belonging to a distinct, though unnamed, genus.

31. **Streptoceras** Billings

Plate XLVII, figs. 1 A–C

Genotype: *Streptoceras Janus* Billings, Cat. Sil. Fossils of Anticosti, Geol. Surv. Canada, 1866, p. 88, fig. 28.

Conch similar to *Amphicyrtoceras* in its general outline and in the structure of its siphuncle, but differing in the tendency of the conch to enlarge in the immediate vicinity of the aperture, the median part of the ventral wall curving outward at the aperture, and the general outline of this aperture being distinctly triangular. The dorso-lateral and ventral angles of this outline are distinctly more narrowly rounded, and the ventro-lateral parts of the outline tend to be slightly concave. From Grimsby, Ontario, Canada; in the Lockport member of the Middle Silurian.

Evidently *Streptoceras* is a direct derivative from *Amphicyrtoceras*. A tendency toward a similar structure is seen in occasional specimens of *Amphicyrtoceras orcas*. In the hundreds of individuals of the latter species examined, almost all specimens show merely the slight downward curvature of the margin of the aperture at the hyponomic sinus, no outward curvature of the median part of the ventral wall being present. However, in occasional specimens this median part of the ventral wall curves slightly outward near the aperture, though not as pronounced as in typical *Streptoceras*.

32. **Paracleistoceras** Gen. nov.

Plate XLV, figs. 3 A–C

Genotype: *Phragmoceras devonicans* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 238, pl. 107.

Conch similar to *Poterioceras* in vertical outline, but with its maximum dorso-ventral diameter distinctly above the base of the living chamber. The ventral side is most gibbous about two-fifths of the height of the living chamber above its base, and the dorsal side is most gibbous at mid-height of this chamber, the lower part of the dorsal outline, along the phragmacone, being slightly concave. Along the greater part of the conch the dorso-ventral and lateral diameters are nearly equal, but toward the aperture the cross-section is distinctly, though moderately, depressed. The dorsal side of the conch is more or less distinctly flattened, compared with its ventral side. The most

distinctive feature of *Paracleistoceras* from *Poterioceras* is the outline of its aperture, which is distinctly triangular, though with rounded dorso-lateral and ventral angles. The ventro-lateral parts of the outline are concave. This form of aperture occurs also in *Acleistoceras*, but the conch of the latter is almost straight. The sutures of the septa curve only slightly downward laterally, and are nearly at right angles to the curving vertical axis of the conch. The siphuncle is in contact with the ventral wall of the conch and its interior is occupied by converging vertical lamellae. From Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

33. **Acleistoceras** Hyatt

Plate XLIV, figs. 6 A–C

Genotype: *Apioceras olla* Saemann, Palaeontographica, vol. 3, 1854, p. 163, pl. 19, figs. 1 A–C. See also *Gomphoceras plenum* Hall, Pal. New York, Suppl. to vol. 5, pt. 2, in vol. 7, 1888, p. 33, pl. 121A, figs. 3, 4.

Genus apparently closely related to *Paracleistoceras*, but the conch, as far as known, is nearly straight, its ventral outline is slightly more convex than the dorsal. Possibly a distinct curvature of the vertical axis of the conch might be detected if the apical end of the latter were at hand. The cross-section of the conch is nearly circular, its depression, when present, being only slight. The maximum diameter of the conch is several camerae below the base of the living chamber. The upper part of the ventral outline, along the living chamber and along the upper part of the phragmacone, slopes distinctly backward, and the conch here contracts laterally as well as dorso-ventrally. The outline of the aperture is distinctly triangular, as in *Paracleistoceras*, but its ventro-lateral parts slope gently downward from the dorso-lateral angles toward the hyponomic sinus, and do not rise in the form of distinct crests, separated by dorso-lateral sinuses from the dorsal outline of the aperture. The greatest difference between *Acleistoceras* and the Bohemian genera *Paracleistoceras* and *Poteriocerina* is presented by the

structure of its siphuncle. The segments of this siphuncle are nummuloidal, with strongly convex lateral outline, but strongly flattened at top and bottom in a direction parallel to the septa, and overlapping in a scalariform or stair-like manner. The siphuncle is located close to the ventral wall of the conch, but not in contact with the latter. From Columbus, Ohio; in the Columbus or Onondaga member of the Middle Devonian.

The septal necks of *Acleistoceras eximium* Hall are lined with calcareous deposits which in the figures published by Hall (loc. cit., pl. 120) appear like short converging vertical lamellae. The radiating lines along the lower surface of casts of the interior of the segments of the siphuncle in *Acleistoceras mitra* Hall (idem., pl. 121) may have had a similar origin. Both of these species are from the same locality and horizon as the genotype, *Acleistoceras olla.*

34. **Cyrtoceras** Goldfuss

Plate XXXV, figs. 1 A, B; plate XLVI, figs. 1 A, B; 2 A; B

Genotype: *Cyrtoceras depressa* Goldfuss, in de la Beche, Handbuch der Geognosie, Von Dechen's German translation, 1852, p. 536. First figured and described by Bronn in Lethaea Geognostica, 2nd ed., vol. 1, 1837, p. 101, pl. 1, fig. 5. See also Foord, Cat. Foss. Ceph. in British Museum, pt. 1, 1888, p. 262, figs. 46 A, B; Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 530.

Conch large, strongly curved lengthwise, and enlarging rapidly both dorso-ventrally and laterally as far as the base of the living chamber. The living chamber is short, and is contracted to an aperture similar to that of *Acleistoceras.* The cross-section varies from nearly circular at the base of the phragmacone to subtriangular at its top, the dorsal side of the upper part of the phragmacone being broadly but slightly concave. The sutures of the septa curve slightly downward dorso-laterally, and rise at increasing slope toward the ventral side of the conch on approaching the top of the phragmacone. The siphuncle is located close to the ventral wall of the conch. Dorso-ventrally it pre-

sents a scalariform arrangement of segments, and its interior is occupied by converging vertical lamellae. From Gerolstein, Eifel, Germany; in the Middle Devonian.

All that is known of the living chamber and aperture of *Cyrtoceras* is the information furnished by Hyatt. In the Proc. Boston Soc. Nat. Hist., 1884, p. 281, he stated regarding *Cyrtoceras depressum*, under *Cranoceras:* "The type has a very short living chamber, and aperture very similar to that of *Maelonoceras praematurum*, but wider transversely and with deep ventral sinus, as in some species of *Acleistroceras*." In the Proc. Amer. Phil. Soc., vol. 32, 1894, p. 528, Hyatt stated: "A very large and remarkable specimen in the Schultze collection, Mus. of Comp. Zoology, shows a very short living chamber, which has an aperture very broad transversely and with a nephritic outline and apparently very broad and well-marked impressed zone." This probably is the same specimen as that described in the preceding publication, but here is recognized as that of an undescribed species. In Zittel-Eastman, Text-book of Paleontology, 1900, p. 530, Hyatt gave the following description of the aperture: "Aperture contracted in gerontic stage to a T-shaped opening, and placed at an acute angle with the central axis, so that the dorsal side is very much shorter than the ventral."

Two specimens at the U. S. National Museum, assumed to be ong to *Cyrtoceras*, have been sectioned dorso-ventrally through the siphuncle, and neither of these presents the nummuloidal form of segments mentioned by Hyatt in Zittel-Eastman.

35. **Cyrtactinoceras** Hyatt

Plate XXXVII, figs. 3 A–C, 4 A–E

Genotype: *Cyrtoceras rebelle* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, pl. 164. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 528.

Conch slightly curved lengthwise, with the ventral side convex and the dorsal side concave; strongly depressed dorso-ventrally, especially along the living chamber and the upper part of the phragmacone. At the base of the phragmacone, the siphuncle

is very near the ventral wall of the conch and is actinoceroid in structure, while toward the living chamber it is much nearer the center of the conch, but remains ventrad of the center, and its form is more orthoceroid. In other words, the segments of the siphuncle are obliquely globular at the lower end of the specimen figured, their lateral diameter and vertical height being about the same. The segments are strongly contracted at the septal necks, and the latter are very short and cyrtochoanitic in structure. The interior of these segments is more or less occupied by calcareous deposits which begin along the inner surface of the septal necks and grow thence toward the interior, upward and downward, so as to present lunate vertical sections as in the Annulosiphonata of Hyatt. Toward the upper part of the phragmacone these obliquely globular segments change first to more narrowly elongate elliptical forms, and then become nearly cylindrical as in many of the orthochoanitic forms. In the latter, the septal funnels are nearly cylindrical in form, and do not curve strongly outward at their bases, as in the cyrtochoanitic species. No trace of converging vertical lamellae are present within the siphuncle.

The living chambers referred by Barrande to the same species as the phragmacones just described are equally depressed dorso-ventrally, and present the siphuncle at their base in the same location as that in which it occurs at the top of the associated phragmacones. Nevertheless, it should be noted that the suture of the septum at the base of the living chamber slopes distinctly downward from the dorsal toward the ventral side of the conch, while the the sutures at the top of the accompanying phragmacone appear to have a different course. The living chamber figured contracts toward its top both dorso-ventrally and laterally. The margin of the aperture slants downward from the dorsal toward the ventral side at a moderate angle, but sufficient to suggest the presence of a hyponomic sinus along the median part of the ventral side, this sinus probably being of small depth. From Bubovitz, Bohemia; in the Middle Silurian; in Barrande's horizon e2.

Cyrtoceras botulus Barrande (loc. cit., p. 580, pl. 145) is founded

on a living chamber and on the upper part of a phragmacone. These agree in being circular in cross-section and in showing but little curvature lengthwise; but, otherwise, there appears little reason for regarding these two fragments as belonging to the same species. The living chamber agrees with that of *Cyrtactinoceras rebelle* in the direction of the slant and in the character of the sinuosity of the suture of the septum at its base. The phragmacone, however, has a circular, instead of a depressed cross-section, and its siphuncle remains near the ventral side of the conch even at the top of the phragmacone, instead of shifting its location to a point nearer the center of the conch. The chief interest in this phragmacone consists in the presence of converging vertical lamellae within its siphuncle. Found at Hlubocep, Bohemia; in the Middle Devonian; at Barrande's horizon g3.

VIII. DEPRESSED CYRTOCERACONES WITHOUT HYPONOMIC SINUS

As already stated, *Poteriocerina* appears to have a transversely elliptical aperture, without a hyponomic sinus; it presents a poterioceroid outline.

In *Conostichoceras* and *Turnoceras* the conch appears to enlarge as far as the aperture. The latter is supposed to be transversely elliptical, without a hyponomic sinus. In *Conostichoceras* the segments of the siphuncle enlarge toward their bases in a truncated conical manner, their lower halves being annular, and presenting an appearance similar to that of the Annulosiphonata, but Barrande described their structure as consisting of converging vertical lamellae. *Turnoceras* presents a similar appearance, but the segments of its siphuncle show concave vertical outlines.

Gonatocyrtoceras presents a lateral outline somewhat similar to that of *Poteriocerina*, but the conch is much more strongly curved lengthwise, and its dorsal side is concave along its entire length.

36. **Conostichoceras** Gen. nov.

Plate XXXVIII, figs. 1 A–E

Genotype: *Cyrtoceras Palinurus* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 37, pls. 466 467, 471.

Conch cyrtoceraconic, rapidly enlarging as far as the aperture, depressed dorso-ventrally, with the siphuncle located close to the convex ventral side of the conch. The living chamber enlarges both dorso-ventrally and laterally as far as it is preserved. The cross-section is broadly elliptical, with the dorsal side somewhat flattened. The sutures of the septa are relatively straight and nearly at right angles to the curving longitudinal axis of the conch. The siphuncle probably is in contact with the ventral wall along the lower part of its segments. These segments have a very unique outline, being enlarged in an annular manner along their lower halves, and contracting toward their top in a truncated conical manner. The calcareous deposit filling these segments resembles that of an actinoceroid cephalopod, rather than that of one of the Actinosiphonata, but Barrande describes this deposit as consisting of converging vertical lamellae. Its actinoceroid appearance is increased by the presence of the transverse line at the upper part of the annular enlargement of the deposit. In actinoceroids this line usually marks the area of contact between the deposits which envelop the inner surface of the septal necks, and thence grow upward and downward until those of successive necks meet at mid-height within the camerae. The specimen figured by Barrande on his plates 466 and 467 has been selected as the genotype. The specimen figured on plate 471 may belong to a distinct species. It enlarges less rapidly, and possibly contracts toward the aperture. Apparently it is gibbous along the lower part of the living chamber and the upper part of the phragmacone on the dorsal side of the conch. The siphuncle appears to be smaller. Both specimens were found at Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3. Plate XXXVIII, figs. 1 A–E.

Cyrtoceras laetificans Barrande (loc. cit., p. 29, pl. 468), from the same locality and horizon, may belong to the same genetic group as *Conostichoceras palinurus*, though nothing is known of the vertical outline of its siphuncle beyond the fact that its basal part is in contact with the ventral wall of the conch, while the upper part of the same segment remains free. The conch is more slender, and its living chamber contracts slightly toward the aperture; the latter, however, remains widely open. The transverse striae are almost directly transverse dorsally and laterally, but their ventral course is unknown. The septal necks are outlined distinctly, and are about half as long as the vertical height of the camerae. The interior of the siphuncle is occupied by converging vertical lamellae.

37. **Turnoceras** Gen. nov.

Plate LIII, figs. 2 A–C

Genotype: *Cyrtoceras Turnus* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 46, pls. 483, 484.

Conch with a strongly curving phragmacone and a straight living chamber, resulting in a geniculate appearance at the upper part of the ventral side of the phragmacone. The phragmacone enlarges rapidly dorso-ventrally as far as its top, and the living chamber remains of the same dorso-ventral diameter or contracts faintly. In a lateral direction the phragmacone enlarges even more rapidly and this enlargement continues along the lower part of the living chamber. There is no evidence of any contraction of this chamber to a T-shaped opening, such as is described by Hyatt for *Cyrtoceras*. In general, the cross-section changes from nearly circular at the base to depressed elliptical along the living chamber. The sutures of the septa are directly transverse to the curving longitudinal axis of the conch. The siphuncle is very near the ventral wall. Its segments present concave vertical outlines, and its interior is occupied by converging vertical lamellae. From Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

38. **Poteriocerina** Gen. nov.

Plate XLV, figs. 1 A–C, 2

Genotype: *Cyrtoceras lumbosum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 33, pls. 470, 464, 465.

Conch resembling *Paracleistoceras* in its general vertical outlines, but its maximum dorso-ventral diameter is distinctly below the base of the living chamber, being located near the base of the fourth camera from this chamber. Moreover, its cross-section is rather strongly depressed dorso-ventrally, and its dorsal side is more or less distinctly flattened. Finally, the outline of its aperture, if correctly determined, is transversely elliptical, without any indication of a distinct hyponomic sinus, no matter how shallow. The siphuncle is almost in contact with the ventral wall of the conch. Its segments are cylindroid, contracting but slightly at the septal necks. Its interior is occupied by converging vertical lamellae. As a genotype, the specimen figured by Barrande on his plate 470 has been selected. From Hlubocep, Bohemia; in the Middle Devonian: at Barrande's horizon g3.

39. **Gonatocyrtoceras** Gen. nov.

Plate LI, figs. 3 A–D

Genotype: *Cyrtoceras heteroclytum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 550, pl. 118, figs. 15–18.

Conch depressed dorso-ventrally, especially at the base of the living chamber; dorsal side more flattened than the ventral one. Strongly curved lengthwise, more or less knee-like in appearance on lateral view. The conch enlarges conspicuously in a lateral direction for about half its length, and then contracts toward the aperture, but its lateral enlargement is much greater than its dorso-ventral one, giving the conch a very obese appearance when viewed from its dorsal or ventral side. The aperture is transversely elliptical in outline, without any angulation suggesting a hyponomic sinus. The siphuncle is located close to the ventral wall of the conch.

Cyrtoceras postscripti Barrande (loc. cit., pl. 493, figs. 8–10), from Hlubocep presents a somewhat similar appearance, but there is no conspicuous narrowing of the upper part of the conch, along the living chamber, as in the preceding species.

IX. COMPRESSED ENDOGASTRIC CYRTOCERACONES

Protophragmoceras and *Endoplectoceras* both have nummuloidal segments of the siphuncle, the latter being endogastric in location, but the conch of *Endoplectoceras* enlarges much less rapidly. *Archiacoceras* is strongly gibbous ventrally, a considerable distance beneath the top of the phragmacone, and its dorsal outline is gently concave. *Danaoceras* and *Codoceras* are similar in general outline; both are curved at early stages of growth, and become nearly orthoconic at later stages. But in *Danaoceras* the siphuncle is close to that side of the conch which is concave at early stages of growth, while in *Codoceras* the siphuncle is merely slightly nearer this concave ventral side than to the convex dorsal side of the conch.

40. **Protophragmoceras** Hyatt

Plate XXXVII, figs. 1 A–D

Genotype: *Cyrtoceras Murchisoni* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 687, pls. 148, 160, 165, 176, 200. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 532, fig. 1086.

Conch breviconic, strongly curved lengthwise, compressed laterally, endogastric, with the siphuncle located close to its concave ventral side. The conch enlarges as far as its aperture, there being no contraction as in *Phragmoceras*. The transverse striae on the surface of the shell curve downward both on the ventral and on the dorsal sides of the conch, but along the median part of the ventral side their downward curvature is more abrupt and along a more narrow angle, thus indicating the location of the hyponomic sinus. The sutures of the septa curve strongly upward dorsally. The segments of the siphuncle are distinctly nummuloidal, broader than tall, narrowing strongly at the septal

necks, the latter being of very small length. No converging vertical lamellae are found within the siphuncle. From Dlauha-Hora and elsewhere in Bohemia; in the Middle Silurian, at Barrande's horizon E. Plate XXXVII, figs. 1 A–D.

Cyrtoceras Beaumonti Barrande (loc. cit., p. 685, pl. 165) is more strongly curved lengthwise, but its chief distinction consists in the presence of short converging vertical lamellae within its siphuncle, located chiefly along the lower part of the individual segments. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon e2.

41. **Endoplectoceras** Gen. nov.

Plate XXXIV, figs. 4 A–D

Genotype: *Cyrtoceras secula* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 239, pl. 510.

Conch compressed laterally, endogastric, rather slowly enlarging, and strongly curved lengthwise. The aperture of the living chamber, as far as known, is elliptical in outline, with its major diameter in a dorso-ventral direction, and its margin slopes downward from the convex dorsal side of the conch toward its concave ventral side. The transverse striae on the surface of the shell are straight, and do not curve downward ventrally so as to locate a hyponomic sinus. The siphuncle is relatively large, and is located near the ventral side of the conch. Its segments are broadly nummuloidal in form, but contract strongly at the septal necks. No converging vertical lamellae are present. From the Vallon de Slivenetz, Bohemia; in the Middle Silurian. Plate XXXIV, figs. 4 A–D.

Endoplectoceras differs from *Protophragmoceras* in the much smaller rate of increase in size of its conch, and in the absence of any indication of a hyponomic sinus along the median part of its ventral side.

Trochoceras inexpectatum Barrande (loc. cit., pl. 491) is similar to *Endoplectoceras secula* in the endogastric location of its siphuncle, and in the lateral compression of its conch. It may be congeneric, but the structure of its siphuncle is unknown. From

Kuchelbad, Bohemia; in the Middle Silurian, at Barrande's horizon e2.

42. **Archiacoceras** Gen. nov.

Plate XLIII, figs. 3 A, B

Genotype: *Phragmoceratites subventricosus* d'Archiac and de Verneuil, Trans, Geol. Soc. London, ser. 2, vol. 6, 1842, p. 351, pl. 30, figs. 1, 1 A.

Conch compressed laterally, endogastric, with the ventral side slightly concave and the dorsal side more strongly convex. The maximum dorsal convexity is about 9 camerae below the top of the phragmacone, a feature not known in any other endogastric genus so far described. The siphuncle is located along the concave ventral side of the conch, and no trace of converging vertical lamellae has been detected within its interior. From Refrath, in the Eifel, Germany: in the Middle Devonian. Plate XLIII, figs. 3 A, B.

Cyrtoceras obliquum Foord (Catalogue of Fossil Cephalopoda, pt. 1, 1888, p. 269, figs. 47 A, B), from the Middle Devonian at Gerolstein, Eifel, Germany, differs in enlarging more slowly, and in having a nearly circular cross-section. As far as known, its greatest dorso-ventral diameter does not lie distinctly beneath the base of the living chamber as in typical *Archiacoceras*, though apparently the type of this species retains the top of the phragmacone, judging from the shortening of the height of the camerae at the top of the part preserved.

43. **Danaoceras** Gen. nov.

Plate XXXVI, figs. 2 A–C

Genotype: *Cyrtoceras Danai* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 654, pl. 171.

Conch similar to that of *Codoceras* in its general outline, and in its endogastric structure, but with the siphuncle located almost in contact with the ventral side of the conch. As in *Codoceras*, this ventral side is distinctly concave only along the lower part of its outline. The conch is compressed laterally. The segments

of the siphuncle are cylindroid not only along the lower part of the phragmacone but also farther up. The interior of the siphuncle contains converging vertical lamellae. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

Cyrtoceras insociale Barrande (loc. cit., p. 666, pls. 148, 159, 166), from the same locality and horizon, is similar to *Danaoceras danai* in its general form and structure, but its siphuncle does not contain converging vertical lamellae. It is of interest chiefly because the margin of its aperture curves downward more angularly along the median part of its ventral side than along its convexly curved dorsal side, thus locating the hyponomic sinus on that side of the conch which is concavely curved toward its apical end, and it is the presence of the hyponomic sinus which identifies a side as ventral.

44. **Codoceras** Hyatt

Plate XXXVI, figs. 1 A–E

Genotype: *Cyrtoceras indomitum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 700, pl. 162. See also Hyatt in Zittel-Eastman, Text-book of Paleontology, 1900, p. 532.

Conch breviconic, compressed laterally, ventral side concavely curved near its apical end, the siphuncle endogastric, located slightly ventrad of the center of the conch. The ventral side of the conch is identified by the presence of the hyponomic sinus, successive stages of the latter being indicated by the distinct downward curvature of the transverse striae on the surface of the conch along the median part of its concavely curved side. This concave curvature is confined to the apical part of the conch, the upper part of the ventral outline being comparatively straight. The dorsal outline is more evenly convex. The segments of the siphuncle present cylindroid outlines along the lower part of the phragmacone, but these gradually widen until, at the top of the phragmacone, they assume distinctly nummuloidal outlines. The interior of the siphuncle is occupied by converging vertical lamellae. From Lochkov, Bohemia; in the Middle Silurian, at Barrande's horizon E.

X. LEPRESSED ENDOGASTRIC CYRTOCERACONES

In *Clinoceras*, the conch is slightly curved, and enlarges slowly, contracting distinctly a short distance before reaching the aperture, and then enlarging again. The siphuncle is slightly nearer the concavely curved side of the conch. Its segments are nearly cylindrical, but contract abruptly at the septal necks.

In *Coelocyrtoceras* the siphuncle is in contact with the concave ventral wall of the conch, and its segments are nearly globular in form.

45. **Clinoceras** Mascke

Plate XXXVII, figs. 2 A–F

Genotype: *Clinoceras dens* Mascke, Zeits. d. Deutschen Geologischen Gesellschaft, vol. 28, 1876, p. 49, pl. 1, figs. 1 A–K.

Conch very slightly curved, cross-section strongly depressed dorso-ventrally, location of siphuncle endogastric, distinctly ventrad of the center of the conch. This species presents a number of anomalous features. Its ventral side is almost straight or only faintly concave, and its dorsal side is only slightly convex, its greatest convexity being along the lower part of the phragmacone. The conch is strongly constricted along the upper half of the living chamber and than enlarges again toward the aperture. The ventral side of the conch is somewhat flattened, especially toward the living chamber. The septal necks are short and curve strongly outward along their lower margins, as in the cyrtochoanitic forms, but the connecting rings are cylindrical along most of their length, though narrowing abruptly at their base. This combination of cyrtochoanitic septal necks with narrowly cylindrical connecting rings is known so far only in this genus, though a similar combination in which the connecting rings are more broadly oblong in outline occurs in *Amphicyrtoceras*, *Streptoceras* and *Monocyrtoceras*. No converging vertical lamellae are present. From erratic rocks of Ordovician origin at Königsberg, Prussia, Germany.

46. **Coelocyrtoceras** Gen. nov.

Plate XXXVII, figs. 5 A, B

Genotype: *Cyrtoceras ventralisinuatum* Sandberger, Versteinerungen des Rheinischen Schichtensystems in Nassau, 1850–56, p. 146, pl. 14, figs. 3, 3a.

Conch moderately curved, strongly depressed dorso-ventrally, with the siphuncle endogastric in location, apparently being in contact with the concave ventral side of the conch. The rate of enlargement of the conch is relatively small, especially in a lateral direction. The dorso-ventral diameter equals about two-thirds of the length of the lateral one. The transverse striae on the surface of the shell curve strongly downward along the median part of the concave ventral side of the conch, forming a V-shaped angle, thus locating the hyponomic sinus. The segments of the siphuncle are obliquely globular in form, and the interior of the siphuncle is occupied by converging vertical lamellae. From Wissenbach, Germany; in the Middle Devonian.

XI. PHRAGMOCEROIDS WITH DORSAL MARGIN OF APERTURE CONVEX

Phragmoceras and *Bolloceras* are conspicuously endogastric genera, the lengthwise curvature of the conch being strong. In *Phragmoceras* the dorsal lobe of the aperture is transversely elliptical. In *Bolloceras* it is narrowed dorso-ventrally into two lateral lobes, as in *Mandaloceras*, but the median part of the dorsal margin of this aperture is slightly convex, instead of concave.

The conch of *Tubiferoceras* is erect, but its vertical outline suggests origin from an endogastric stock. The dorsal lobe of the aperture is supported by a neck-like protuberance from the rear of the living chamber, which curves upward. At its contact with the living chamber this neck is partially separated from the interior of the latter by a flat partition which projects upward and inward.

Typical *Gomphoceras* has an erect conch in which the dorsal lobe of the aperture is elliptical, and elongated in a dorso-ventral direction. The ventral end of the aperture is conspicuously

narrower, and terminates in a spout-like projection. Immediately beneath this projection the ventral outline of the living chamber cuves inward as in *Trimeroceras* and *Mandaloceras*.

Clathroceras has an aperture similar to that of typical *Gomphoceras*, but with the dorsal lobe circular in outline. The conch is curved distinctly lengthwise, with the siphuncle exogastric, instead of endogastric as in *Phragmoceras*.

Inversoceras is another exogastric genus, with an aperture similar to that of some species of *Phragmoceras*, notched along the lateral walls of its dorsal lobe.

The preceding genera are not closely related.

47. **Phragmoceras** Broderip

Plate XLVIII, figs. 1 A, B

Genotype: *Phragmoceras arcuatum* Sowerby, in Murchison's Silurian System, 1839, p. 621, pl. 10, fig. 1 A. See also Blake, British Fossil Cephalopoda, 1882, p. 204, pl. 26, fig. 1, 1 A.

Conch strongly compressed laterally, and strongly curved lengthwise, the siphuncle being located close to its concave ventral side. Excepting at its dorsal end, the aperture of the living chamber is contracted by the strong inward curvature of its dorso-lateral crests to a narrow slit, terminating ventrally in a slightly enlarging hyponomic sinus, which forms the upper margin of a projecting lip or spout. At its dorsal end, this narrow slit widens abruptly into an elliptical dorsal lobe, distinctly wider laterally than long dorso-ventrally. The dorsal margin of this lobe is evenly convex in outline. The margin of this lobe rises diagonally upward and backward in the form of a short collar. The transverse striae ornamenting the surface of the shell curve more strongly down dorsally than ventrally; nevertheless the location of the hyponomic sinus is ventral. The segments of the siphuncle are nummuloid in outline. From Ludlow or Ludbury, England, in the Lower Ludlow member of the Middle Silurian.

Since *Phragmoceras arcuatum* is described first under the generic name *Phragmoceras*, it usually is cited as the genotype of that genus, though *Phragmoceras ventricosum*, described second, ap-

parently furnished the details used in describing the characteristic form of the aperture. However, at present, through the efforts of Blake, the outline of the aperture of *Phragmoceras arcuatum* is well known, and its value as a genotype is unquestioned.

The Devonian phragmoceroids of Bohemia include at least 7 species in which the siphuncle contains converging vertical lamellae. Among these 7 species, 3 are known to have cylindrical or cylindroid siphuncles, the structure of the siphuncle of the other 4 species being unknown. Further study may result in the discovery of other differences between the phragmoceroids of Devonian age and the typical Silurian forms.

In *Phragmoceras dux* (loc. cit., pls. 531, 532, 533) and in *Phragmoceras inflexum* (pl. 540), the segments of the siphuncle present straight vertical outlines. In *Phragmoceras comes* (pls. 63, 244, 455, 491) the vertical outline of these segments is slightly convex, except at their bases.

Phragmoceras baro (pl. 454) has a low dorsal collar. In *Phragmoceras princeps* (pl. 457) the lateral margin of the dorsal lobe of the aperture is incised into relatively broad sinuses. In the species figured on plate 543 under *Phragmoceras hospes*, these lateral sinuses are much narrower and are deflected obliquely downward and forward. *Phragmoceras Bohemicum* (pls. 533, 534) is an aberrant species in which the trapezoidal dorsal lobe of the aperture faces directly backward.

All of the Devonian species here named are from Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

48. **Bolloceras** Gen. nov.

Plate XLVIII, figs. 3 A–C

Genotype: *Phragmoceras rex* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 215, pls. 61, 62, 101.

Conch differing from typical *Phragmoceras* chiefly in the outline of the dorsal lobe of its aperture. The latter is constricted dorsoventrally to an almost linear transverse slit, the median part of

whose posterior margin is slightly convex. From Hlubocep Bohemia; in the Middle Devonian, at Barrande's horizon g3.

Phragmoceras pigrum (loc. cit., p. 214, pls. 64, 65), *Phragmoceras gutterosum* (p. 211, pls. 100, 244), and the type of *Phragmoceras clypeatum* (p. 234; also Suppl., p. 228, pl. 536), from the same locality and horizon as the genotype, are congeneric. *Phragmoceras Forbesi* (Suppl., p. 231, pl. 520) from the same horizon in the Tachlovitz valley, may be closely related to *Phragmoceras clypeatum.* In *Phragmoceras bolli* (Suppl., 1877, p. 77, pl. 454), from Hlubocep, the dorsal lobe as a whole is curved in a transversely lunate manner, with its convex side facing posteriorly. All of the species mentioned here, including the genotype, have converging vertical lamellae.

49. **Tubiferoceras** Hedström

Plate XLVIII, figs. 2 A–C

Genotype: *Phragmoceras proboscideum* Hedström, Ueber die Gattung Phragmoceras in der Obersilurformation Gotlands, 1917, pp. 8, 11, pl. 1, figs. 1–10.

Conch erect, short, rapidly expanding, especially dorso-ventrally. Ventral outline nearly straight or only slightly convex. Dorsal outline more distinctly convex, especially along the upper part of the phragmacone and the lower part of the living chamber. The aperture resembles that of typical *Phragmoceras;* however, its dorsal lobe forms the upper margin of a dorsal collar which projects rather abruptly from the upper part of the living chamber, first backward and then upward. Along the line of junction of this collar with the dorsal wall of the remainder of the living chamber, a partial partition extends diagonally upward and ventrad, ending abruptly interiorly. The plane of this partition is approximately parallel to the line of junction between the dorsal collar and the dorso-lateral walls of the living chamber. In addition to the genotype, Hedström described also *Tubiferoceras prominens* and *Tubiferoceras prominens* var. *minus,* all from Gotland, Sweden, in the Middle Silurian.

Hedström referred to this genus also the *Phragmoceras labiatum*

Whitfield (Geol. Wisconsin, vol. 4, 1882, p. 302, pl. 20, figs. 1, 2), from the Racine member of the Middle Silurian of Wisconsin. Another American species is *Trimeroceras gilberti* Kindle and Breger 28th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1904, p. 475, pl. 15, fig. 1), from Huntington and Delphi, Indiana, in the Middle Silurian.

Phragmoceras Verneuili Barrande (Systeme Silurien du Centre de la Boheme, 2, 1867, pl. 66) presents a similar structure, but its siphuncle contains converging vertical lamellae. From Hlubocep, Bohemia, in the Middle Devonian, at Barrande's horizon g3.

50. **Gomphoceras** Sowerby

Plate XLIX, figs. 1 A, B; 2 A, B

Genotype: *Orthoceras pyriforme* Sowerby, in Murchison's Silurian System, 1839, p. 620, pl. 8, fig. 19, upper figure under this number only. See also Blake, British Fossil Cephalopoda, 1882, p. 192, pl. 22, figs. 2, 2 A.

Conch erect, with its dorsal outline slightly more convex; enlarging to a level distinctly above the base of the living chamber, thus producing the pyriform outline characteristic of the type. Living chamber contracted above mid-height to a narrow aperture. This aperture broadens posteriorly to a dorsal lobe, and narrows anteriorly to a linear hyponomic sinus, terminating ventrally with a protruding lip. The ventral outline of the living chamber immediately beneath this lip curves inward or backward, instead or outward or forward as in *Phragmoceras*. The dorsal lobe is elongated in a dorso-ventral direction in an elliptical manner, and there is no incurvature of its dorsal margin as in *Conradoceras*, *Mandaloceras*, and other related genera. From Leintwardine, Great Britain; in the Lower Ludlow member of the Middle Silurian.

Our knowledge of the aperture of the genotype is derived from Blake, in the publication cited above, especially from figure 2 A on his plate 22. This figure shows the elongate elliptical outline of the dorsal lobe of the aperture, without any trace of a concave posterior margin. Similar dorsal lobes have been drawn from

Sowerby's type and from the specimen illustrated by Blake, on plate XLIX of the present bulletin. These figures were prepared from casts of the original specimens kindly prepared for the writer by Dr. F. A. Bather, keeper of the department of Geology of the British Museum of Natural History. Until this knowledge is improved by the finding of additional specimens in which the outlines of the dorsal lobe of the aperture are more clearly defined, it seems necessary to conclude that only one species of *Gomphoceras* is known at present, and that is the genotype.

Recently Hedström (Sveriges Geol. Undersökning, ser. Ca, No. 15, 1917, p. 6) has defined *Gomphoceras* as follows: The genus *Gomphoceras* can among other things be distinguished from *Phragmoceras* by the fact that the dorsal margin of the aperture always is curved inward (forming a broad, sometimes two-lobed crest), while on the contrary the dorsal margin in the latter genus is curved outward or upward. As thus defined, *Gomphoceras* would include the genera *Mandaloceras, Hemiphragmoceras, Tetrameroceras, Conradoceras, Hexameroceras, Pristeroceras,* and *Octameroceras.* This could be done only by selecting as the genotype Sowerby's second specimen figured under 19. The latter, however, was recognized by M'Coy as forming a distinct species, and was named by him *Poterioceras ellipticum* in 1851. According to the Hyatt nomenclature it belongs to the genus *Mandaloceras.*

51. **Clathroceras** Gen. nov.

Plate LI, figs. 1 A–E

Genotype: *Phragmoceras sulcatum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 239, pl. 47, figs. 8–13.

Conch curved lengthwise, with the ventral side convex, and the dorsal side concave; enlarging as far as the base of the living chamber and then contracting moderately until within a short distance of the aperture, where the contraction becomes rapid. The aperture consists of a larger, nearly circular, dorsal lobe, from which a much smaller and narrower lobe extends ventrad, thus locating the hyponomic sinus. The siphuncle is located

near the ventral wall of the conch, and its segments are narrowly cylindroid in vertical outline. The surface of the shell is ornamented by numerous narrow vertical ribs, crossed by still more numerous transverse raised lines.

52. **Inversoceras** Hedström

Plate XXXV, figs. 4 A–D

Genotype: *Phragmoceras perversum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 241, pl. 53, figs. 1–6. See also Hedström, Sveriges Geol. Undersökning, ser. Ca, no. 15, 1917, p. 7.

Conch erect; ventral outline moderately convex; dorsal outline concave in general, but faintly convex or nearly straight along the living chamber about halfway between its base and the dorsal collar. The dorsal collar projects upward and backward, and its lateral margin is narrowly incised by a V-shaped lateral sinus. The remainder of the aperture resembles closely that of typical Phragmoceras. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

Inversoceras constrictum Nom. nov. (loc. cit., pl. 53, figs. 13, 14) is distinctly constricted at the base of the dorsal collar, the form otherwise resembling typical *Inversoceras perversum* (Barrande). Hinter-Kopanina, Bohemia.

Inversoceras percurvatum Nom. nov. (loc. cit., pl. 53, figs. 15–19) differs from typical *Inversoceras perversum* chiefly by its much greater lengthwise curvature, the ventral outline being strongly convex. Hinter-Kopanina, Bohemia; in the Middle Silurian.

Inversoceras barrandei Nom. nov. (loc. cit., pl. 53, figs. 20–23) differs from *Inversoceras percurvatum* chiefly in the constriction at the base of the dorsal collar. Hinter-Kopanina.

These forms of *Inversoceras* are of interest chiefly on account of including two species, *Inversoceras constrictum*, and *Inversoceras barrandei*, which differ from two other species, *Inversoceras perversum* and *Inversoceras percurvatum* in the same respect, namely the constriction at the base of the dorsal collar. In

consequence, the query arises whether these differences may not be sexual differences rather than of specific value.

XII. PHRAGMOCEROIDS HAVING APERTURE WITH AZYGOUS DORSAL SINUS

The Trimeroceratidae include the genera *Trimeroceras* and *Pentameroceras*. The former has two lateral sinuses of the dorsal lobe of the aperture; the latter has four; both have in addition to the lateral sinuses a single dorsal sinus directed straight backward. In *Trimeroceras* the conch is compressed laterally; in *Pentameroceras* it is depressed dorso-ventrally. There may be a third genus, *Septameroceras*, with six lateral sinuses in addition to the dorsal azygous one, but the type of that genus can not be found, and *Gomphoceras septore* Hall has no dorsal azygous sinus, the figure published by Hall being in error.

53. **Trimeroceras** Hyatt

Plate XXXVI, figs. 3 A, B

Genotype: *Gomphoceras staurostoma* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 318, pl. 73, figs. 1–3. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 278.

Conch erect, as in *Mandaloceras*, but compressed laterally, and the dorsal lobe of the aperture has three sinuses, a short medio-dorsal sinus as well as two longer lateral ones. The siphuncle is located close to the ventral wall of the conch, and does not contain converging vertical lamellae. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

54. **Pentameroceras** Hyatt

Plate L, figs. 6 A–C

Genotype: *Gomphoceras mirum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 319, pls. 82, 91.

Conch erect as in *Trimeroceras*, but with its ventral outline more convex, and with 5 sinuses emarginating the border of the

dorsal lobe of its aperture. Of these, the posterior sinus is short, the postero-lateral ones extend almost direct laterally, and the anterior ones are oriented antero-laterally. The cross-section of the conch is depressed dorso-ventrally. From Hinter-Kopanina, Bohemia; in the Middle Silurian, at Barrande's horizon E.

55. **Septameroceras** Hyatt

Genotype: *Gomphoceras inflatum* Billings, named but not described. See Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 278; also Whiteaves, Pal. Foss., Geol. Surv. Canada, vol. 3, pt. 2, 1895, p. 102.

Conch with 7 sinuses indenting the margin of the dorsal lobe of the aperture, of which one sinus is directed backward, while the others are arranged in three lateral pairs. From L'Anse à la Barbe, near Port Daniel, Baie des Chaleurs, Quebec, Canada; in the Middle Silurian.

Whiteaves stated that the name *Gomphoceras inflatum* was attached by Billings to a rough cast of the interior of the body chamber of a shell, with the aperture badly preserved, and added that it was difficult to see how this specimen was to be distinguished from *Gomphoceras septore*. Since in the same paragraph Whiteaves, under the name *Gomphoceras septore* Hall, described a specimen from the Guelph at Elora, Ontario, as having six lateral sinuses and an azygos dorsal sinus in the aperture, Whiteaves evidently does not discredit the generic diagnosis of *Septameroceras* presented by Hyatt. The type of *Gomphoceras inflatum* can not be found at present, but should it ever turn up, its name should be ascribed to Hyatt, rather than to Billings.

Unfortunately, the name *Gomphoceras septore* can not be substituted in place of that of *Gomphoceras inflatum* as a genotype of *Septameroceras*, no matter what standing be given to the name *Gomphoceras inflatum*, since the type of *Gomphoceras septore* does not have 7 sinuses along the margin of the dorsal lobe, but only 6. This type, which is numbered 12649 in Walker Museum at Chicago University, has the median part of the dorsal crest between the two posterior lateral sinuses spalled off, and this was incorrectly interpreted by Hall as constituting another sinus.

This does not exclude the possibility of the Elora specimen being a true *Septameroceras*, but the latter also appears to be missing.

The situation as regards *Gomphoceras subgracile* Billings is even worse. Whiteaves refers to this species as though it also had the structure ascribed to *Septameroceras*, but the specimen sent to me by the Victoria Memorial Museum under the name *Gomphoceras subgracile* Billings, and labelled as coming from Port Daniel, has an aperture very similar to that of *Gomphoceras scrinium* Hall, which provisionally is referred to *Mandaloceras*, but probably belongs to a distinct genus. The Port Daniel specimen of *Gomphoceras subgracile* studied by me is numbered 3053.

XIII. PHRAGMOCEROIDS HAVING APERTURE WITH ONLY LATERAL SINUSES

For these the family name Hemiphragmoceratidae is proposed. They include the Genera *Hemiphragmoceras*, *Tetrameroceras*, *Conradoceras*, *Paraconradoceras*, *Hexameroceras*, *Pristeroceras*, and *Octameroceras*. In all of these genera the dorso-ventral outline of the conch suggests origin from an endogastric stock, though the conchs tend to be erect, and some approach closely to this position. The dorsal margin of the aperture, posterior to the rear pair of sinuses, is concave medially. Moreover, the ventral outline of the living chamber curves inward just beneath the projecting spout-like margin of the hyponomic sinus, as in the Trimeroceratidae.

In *Mandaloceras* the conch is slightly depressed dorso-ventrally, and it may have originated from an exogastric stock, similar to *Clathroceras*. In *Hemiphragmoceras*, the conch is compressed laterally. Both genera have only two lateral sinuses.

Tetrameroceras has a vertical outline similar to *Hemiphragmoceras*, but there are 4 lateral sinuses. *Conradoceras* preserves in the adult state a condition through which *Tetrameroceras* passes in earlier stages of constriction of its aperture. *Paraconradoceras* differs from *Conradoceras* chiefly in the concave outlines presented by the segments of its siphuncle. In typical *Hexameroceras* there are six sinuses, of which two are short and

are directed straight backward from the middle part of the dorsal lobe. *Pristeroceras* differs from typical *Hexameroceras* in having the narrow slit between the dorsal lobe of the aperture and its hyponomic termination corrugated with alternating teeth. Typical *Octameroceras* is supposed to have 4 pairs of lateral sinuses, but the anterior pair is poorly developed, and apparently often absent. By a freak of nomenclature the American species usually referred to *Hexameroceras* belong to *Octameroceras*, in which all the sinuses are lateral, rather than to typical *Hexameroceras*, in which two of the sinuses are directed posteriorly.

56. **Mandaloceras** Hyatt

Plate XLVIII, figs. 5 A–C

Genotype: *Gomphoceras Bohemicum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 306, pl. 74. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 531, figs. 1084 A, B.

Conch with an aperture closely similar to that of *Hemiphragmoceras*, but differing from the latter genus in its erect dorso-ventral outline and in the dorso-ventral depression of its cross-section. No converging vertical lamellae are present in its siphuncle. From Dvoretz, Bohemia: in the Middle Silurian, at Barrande's horizon E.

Gomphoceras Verneuili Barrande (loc. cit., pl. 71) is similar in the form of the conch and the outline of the aperture, but the lower part of the ventral outline of the phragmacone is concave, and the interior of its siphuncle contains converging vertical lamellae. These lamellae are short, and embrace the septal necks, as in *Laumontoceras*. From Lochkov, Bohemia; in the Middle Silurian, at Barrande's horizon E.

In most of the species included by Barrande in his group *Dimorion* only the upper part of the conch is known, so that it can not be determined whether the lower part of their ventral outline is concave in a manner similar to that of *Gomphoceras Verneuili* or not.

Depressed cross-sections of the conch are known among phragmoceroids only in the genera *Mandaloceras* and *Pentameroceras*.

57. **Hemiphragmoceras** Hyatt

Plate XLVIII, figs. 4 A–C

Genotype: *Phragmoceras pusillum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 220, pl. 52. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 531.

Conch similar to that of *Tetrameroceras*, but with only two lateral sinuses in the dorsal lobe of the aperture. The median part of the dorsal margin of this lobe is slightly concave, but the distal extremities of its sinuses curve slightly forward. From Lochkov and Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

Phragmoceras pavidum Barrande (loc. cit., p. 219, pl. 51), *Phragmoceras globulosum* Barrande (p. 236, pl. 52), and probably also *Phragmoceras saturum* Barrande (p. 237, pl. 428) are congeneric, and all are from the Middle Silurian.

Among Devonian phragmoceroids, those that have a similar form of aperture include the type of *Phragmoceras hospes* (as illustrated by figure 2 on plate 536), and the specimen represented by figure 2 on plate 537, which is identified with *Phragmoceras clypeatum* by Barrande, but which is regarded here as belonging to a distinct species. The type of *Phragmoceras clypeatum* is referred here to *Bolloceras*.

All of the species of *Hemiphragmoceras* mentioned here have siphuncles containing converging vertical lamellae.

58. **Tetrameroceras** Hyatt

Plate L, figs. 1 A–C

Genotype: *Phragmoceras bicinctum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 222, pl. 51. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 277.

Conch distinctly curved lengthwise, the dorsal side convex,

and the ventral side concave along the phragmacone, but gibbous along the living chamber. The upper part of the ventral outline curves inward directly beneath the protruding lip of the hyponomic sinus. The dorsal lobe presents four lateral sinuses. Of these, the two posterior ones are directed dorso-laterally, and the two anterior ones directly laterally, the posterior margin of the dorsal lobe being distinctly concave. Viewed directly from the rear, however, this concave dorsal margin is formed by a convex dorsal crest which curves upward and forward, and thus indents the posterior margin of the dorsal lobe. From Viscocilka, Bohemia; in the Middle Silurian, at Barrande's horizon E.

Phragmoceras discrepans (loc. cit., p. 223, pls. 49, 51), *Phragmoceras Loveni* (p. 227, pls. 48, 49, 99), *Phragmoceras infaustum* (p. 224, pl. 55), *Phragmoceras problematicum* (p. 229, pl. 54), *Phragmoceras vetus* (p. 231, pl. 54), *Phragmoceras insolitum* (p. 226, pl. 52), and *Gomphoceras Deshayesi* (p. 332, pls. 73, 101) are congeneric, and come from the same horizon. All of these species, including the genotype, contain converging vertical lamellae.

59. **Conradoceras** Gen. nov.

Plate L, figs. 2 A–C

Genotype: *Phragmoceras pseudoconradi* Nom. nov. See *Phragmoceras conradi* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 209, pl. 49, figs. 4–7 only.

Conch similar to that of *Tetrameroceras*, but more erect, and its dorsal lobe presenting a different outline. This lobe is somewhat triangular. Its dorsal margin is broad and slightly concave, and its antero-lateral margins present two scallops or undulations, of which the posterior one is broader and faces directly laterally, while the anterior one faces antero-laterally. This is not an immature form of *Tetrameroceras*, though species of the latter genus must have passed through a similar stage. From Hinter-Kopanina, Bohemia, in the Middle Silurian, in Barrande's horizon e2.

At Harvard University, a specimen numbered 2166A, evidently belongs to the same species, but there are three scallops along the antero-lateral margin of the dorsal lobe of the aperture.

60. **Paraconradoceras** Gen. nov.

Plate L, figs. 5 A–D

Genotype: *Phragmoceras rigescens* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, Suppl., 1877, p. 238, pl. 520.

Conch similar to that of *Conradoceras pseudoconradi*, especially in the outline of the dorsal lobe of its aperture. It differs chiefly in the vertical outline of the segments of its siphuncle, which is concave instead of convex. The distal end of the hyponomic sinus is enlarged in a circular manner, and does not project in the form of a lip or spout. The dorsal outline of the conch is less convex, the ventral outline is slightly concave as far up as mid-height of the living chamber, and the dorso-ventral outline of the conch is more cuneate. The sutures of the septa rise distinctly and increasingly toward the dorsal side of the conch. The interior of the siphuncle contains converging vertical lamellae. From Hlubocep, Bohemia, in the Middle Devonian, at Barrande's horizon g3.

61. **Hexameroceras** Hyatt

Plate L, figs. 3 A–C

Genotype: *Phragmoceras panderi* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 232, pl. 48. See also Hyatt, Proc. Boston Soc. Nat. Hist., vol. 22, 1884, p. 278.

Conch similar to *Tetrameroceras*, but differing in the outline of its dorsal lobe. The latter is contracted to six sinuses, of which the two dorsal ones are short and are directed straight backward, while the ends of the two dorso-lateral sinuses curve slightly backward, and the two antero-lateral sinuses face in the direction indicated by their names. The siphuncle contains converging vertical lamellae. From Dvoretz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

As far as known, *Hexameroceras panderi* (Barrande) and *Pristeroceras timidum* Ruedemann are the only species having dorsal lobes of the aperture with this type of structure.

62. **Pristeroceras** Ruedemann

Genotype: *Pristeroceras timidum* Ruedemann, New York State Museum Bull., No. 265, 1925, p. 57, text-figs. 34–37, pl. 18, figs. 1–7.

Conch similar to that of *Hexameroceras panderi* (Barrande), but differing in the zigzag course of the narrowly constricted part of the aperture which extends between the dorsal lobe and the hyponomic sinus. The dorsal lobe of *Pristeroceras* is closely similar to that of *Hexameroceras panderi*. The two posterior sinuses are short and extend directly backward. The dorso-lateral sinuses curve slightly backward at their ends, and the antero-lateral sinuses extend in the direction indicated by their names. These sinuses are displayed best by figures 1 and 3 on Ruedemann's plate 18. In his figures 2 and 4 the state of preservation of the outline of the aperture may be less perfect or the contraction of the dorsal lobe of the aperture may be in a less advanced stage of development. From Buffalo, New York; in the Bertie member of the Upper Silurian.

63. **Octameroceras** Hyatt

Plate L, figs. 4 A–C

Genotype: *Octameroceras callistomoides* Nom. nov. *Phragmoceras callistoma* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 234, pl. 67; also p. 203. See also Hyatt, in Zittel-Eastman, Text-book of Paleontology, 1900, p. 531.

Conch similar to that of *Tetrameroceras* but more erect, and its dorsal lobe is contracted to a greater number of sinuses. According to Hyatt the number of these sinuses is eight, and *Phragmoceras callistoma* is cited by him as the genotype. Unfortunately the type of *Phragmoceras callistoma*, as figured on Barrande's plate 47, has only six sinuses, so this form evidently was not the one in mind when the generic name *Octameroceras* was proposed. The latter must have been based on the specimen figured under the same name on Barrande's plate 67, in which two additional sinuses are present. The latter, however, is a distinct species. Its conch is more erect, the lower part of its

dorsal outline being concave, and its vertical axis less curved. The narrow slit and projecting lip of the hyponomic sinus slope much less strongly downward. In consequence, the gibbous part of the ventral outline involves a greater length both of the living chamber and of the upper part of the phragmacone. For this reason the name *Octameroceras callistomoides* is proposed here for the specimen illustrated on Barrande's plate 67, and the latter is used as the genotype of *Octameroceras*.

Both species, *Octameroceras callistomoides*, and the species originally described by Barrande as *Phragmoceras callistoma* on his plate 47, present dorsal lobes of the aperture with essentially the same structure. In both species the ends of the posterior sinuses curve slightly forward, and the second and third pairs of sinuses from the rear have the same orientation. The only difference between them consists of the presence of an additional and much smaller pair of sinuses in front of the rest in the genotype *Octameroceras callistomoides*. Hence it would appear feasible to include both forms with six and those with eight sinuses under the name *Octameroceras*.

Unfortunately, in that case by far the greater number of species of *Octameroceras* would consist of forms having only six lateral sinuses along the dorsal lobe of the aperture. A considerable number of American species, some of which have not yet been described, have the form of structure similar to that of typical *Phragmoceras callistoma*, while only *Pristeroceras timidum* Rudemann shares with *Hexameroceras panderi* the peculiar outline of the dorsal lobe of the aperture which the latter species presents. Usually these American species are referred to *Hexameroceras*, but the sinuses of the latter have a sufficiently different orientation to place them in a distinct genus. Under these conditions it seems necessary either to refer the American species to which reference here is made to *Octameroceras* in spite of the etymological significance of this generic term, or to propose a distinct generic name for the latter solely for the purpose of escaping the name *Octameroceras*. The writer prefers the former procedure, though recognizing its weakness.

Among Bohemian species with 6 lateral sinuses of the dorsal

lobe of the aperture, *Gomphoceras pollens* Barrande (loc. cit., p. 333, pls. 85, 91) occurs in the Middle Silurian of Hinter-Kopanina, and *Gomphoceras gratum* Barrande (loc. cit., p. 320, pls. 73, 82) in the Middle Silurian of Bubovitz. Both species contain converging vertical lamellae within their siphuncles.

In North America converging vertical lamellae are known only in a specimen closely resembling or identical with *Gomphoceras septoris* Hall. This specimen is from the equivalent of the Racine at Port Byron, Illinois, and is numbered 2150B in the Museum of Comparative Zoology at Harvard University. The type of *Gomphoceras septoris* Hall, which is numbered 12649 in Walker Museum at Chicago University, does not possess 7 sinuses as suggested by Hall's figure 7 (20th Rept. New York State Can. Nat. Hist., 1868, rev. ed., p. 410), but only 6 lateral sinuses as in the species here discussed.

XIV. COSTATED TROCHOCEROIDS

Hyatt included in his Plectoceratidae the genera *Plectoceras* and *Sphyradoceras*, reducing to synonomy with the latter his former genera *Peismoceras* and *Sphyradoceras*. However, in *Plectoceras* the conch is nautiloid, and is closely coiled around a relatively small umbilical opening, and the location of the siphuncle is near the ventral wall of the conch; while in *Sphyradoceras*, *Systrophoceras*, *Catyrephoceras*, *Leurotrochoceras*, *Lechritrochoceras*, and probably also in *Trochodictyoceras* the location of the siphuncle is central, or slightly ventrad of the center, and the conch is coiled around a much larger umbilical opening in a trochoceroid manner. Only in occasional specimens, such as *Peismoceras optatum* and *Lechritrochoceras placidum*, is the siphuncle near the ventral wall of the conch. In all of these genera the siphuncle is tubular. For the second group of genera, typified by *Sphyradoceras*, the family name Sphyradoceratidae is proposed.

Possibly the Sphyradoceratidae originated from conchs similar to *Centrocyrtoceras*, in which the curvature is gyroceraconic, the umbilical opening wide, the location of the siphuncle central or slightly ventrad of the center, and the course of the transverse

annulations more or less sinuous laterally. In addition to annulations there are numerous transverse striae. The genus makes its first appearance in the Murfreesboro member near the base of the Stones River formation, and occurs as high as the Trenton.

In *Lechritrochoceras* and *Catyrephoceras* transverse striae are present. In *Peismoceras* only longitudinal striae occur. In *Systrophoceras* the striae are longitudinal on the dorsal side of the conch and transverse on its ventral side. In *Sphyradoceras* only the longitudinal striae are conspicuous, the transverse ones being reduced to lines of growth. In *Trochodictyoceras* the surface ornamentation consists of longitudinal and transverse, relatively distant, ribs. The surface ornamentation of *Leurotrochoceras* is unknown.

64. **Centrocyrtoceras** Gen. nov.

Plate XLIII, fig. 5; plate XLV, figs. 4 A–C

Genotype: *Cyrtoceras annulatum* Hall, Pal. New York, vol. 1, 1847, p. 194, pl. 41, figs. 4 A-D, 5; later named *Cyrtoceras subannulatum*, by D'Orbigny, Prodr. Pal., vol. 1, 1849, p. 1.

Conch small, apparently three-fourths of a volution, surrounding an open space about 10 mm. in diameter. Rate of enlargement about 15 degrees. At its larger end the conch attained a diameter of at least 13 mm.; cross-section circular. Location of siphuncle central or slightly ventrad of the center; segments of siphuncle nearly cylindrical. Surface of shell transversely annulated, with a tendency toward a downward curving sinuosity along the middle of the lateral sides. In addition to the annulations there are numerous transverse raised lines. From Middleville, New York; in the Trenton division of the Middle Ordovician. Plate XLV, figs. 4 A–C.

Cyrtoceras sinuatum Billings (Geol. Surv. Canada, Rep. of Progress for 1853–56, publ. in 1857, p. 315; see also Whiteaves, Pal. Foss., vol. 3, 1906, p. 312, pl. 40, figs. 3, 3 A), from the Leray division of the Black River formation, at La Petite Chaudiere, on the Ottawa River in Canada, is a similar species.

Cyrtoceras bondi Safford (Geol. Tennessee, 1869, p. 290, pl. 4,

figs. 3 A-D), from the Murfreesboro member of the Stones River formation, in the Lower Ordovician, differs only in being distinctly compressed laterally, and in having the siphuncle located more distinctly ventrad of the center of the conch.

Gyroceras duplicostatum Whitfield (Geol. Wisconsin, vol. 4 1882, p. 235, pl. 7, fig. 1), from the Platteville member of the Black River formation, is closely related to the preceding species, but the latter is figured as acutely costated. Plate XLIII, fig. 5.

65. **Lechritrochoceras** Gen. nov.

Plate XXXV, figs. 5 A, B

Genotype: *Trochoceras desplainense* McChesney, as figured and described by Hall, in 20th Rept. New York State Cab. Nat. Hist., 1868, p. 401, pl. 16, figs. 8, 9, 10.

Conch trochoceroid in its form of coiling, dextral, consisting as far as known of only a little more than two volutions. When the conch is placed on its side in a position similar to that of a flat-spired gasteropod, the apical end of the conch is about on a level with the upper face of the last volution. Except near the aperture, the two volutions are in contact with each other, a narrow longitudinal impressed zone occurring along the upper inner margin of the last volution. Umbilical opening about 5 mm. or less in diameter. Cross-section of conch circular. The sutures of the septa curve slightly downward laterally and rise slightly ventrally. The location of the siphuncle is slightly ventrad of the center of the conch. Its passage through the septa is small, and the form of its segments is cylindrical. The surface of the shell is marked by relatively prominent transverse annulations or ribs, which curve strongly downward ventrally indicating a relatively deep hyponomic sinus. Parallel to the annulations there are numerous transverse striae. From Racine, Wisconsin; in the Racine member of the Middle Silurian. Type: specimen No. 2126, American Museum of Natural History. Plate XXXV, figs. 5 A, B.

Trochoceras placidum Barrande (Systeme Silurien, pl. 23) from Butovitz, Bohemia, in the Middle Silurian, differs chiefly

in the more ventrad location of its siphuncle and in the direction of curvature of the transverse ribs, whose ventral ends curve less strongly downward than their median lateral parts. Plate XLII, figs. 2 A–C.

Lechritrochoceras is typified by a species in which numerous transverse striae, but no longitudinal ones are present. The siphuncle is central in location, and cylindrical in form.

66. **Catyrephoceras** Gen. nov.

Plate XLIII, fig. 2

Genotype: *Trochoceras giganteum* Blake, British Fossil Cephalopoda, 1882, p. 223, pl. 31, fig. 2.

Conch only moderately asymmetric in its form of coiling, its apical part being shifted less than half the lateral diameter of the living chamber. Its direction of coiling is dextral, and its volutions are barely in contact with each other along the phragmacone and along the lower third of the living chamber. The upper two-thirds of the latter uncoil distinctly from the remainder of the conch. The cross-section is slightly compressed laterally, resulting in a slightly quadrangular outline. The sutures of the septa curve downward laterally. The siphuncle is slightly ventrad of the center of the conch. The transverse annulations or ribs curve increasingly downward ventrally, becoming feeble along the median part of the ventral side. Parallel to the ribs there are faint lines of growth. The most distinguishing feature of the specimen here selected as a type of the genus is the form of its aperture. This aperture is bordered by two lateral crests which curve abruptly inward, leaving between them a dumbbell-shaped opening, elongated dorso-ventrally, enlarging gradually toward its extremities from a narrower mid-length. From Leintwardine, Great Britain; in the Lower Ludlow member of the Middle Silurian.

Catyrephoceras is similar to *Systrophoceras* in its open form of coiling, in the more feeble development of its annulations ventrally, in the presence of transverse striae on the ventral side of the conch, and of longitudinal striae along its dorsal side, and in

the location of the siphuncle ventrad of the center of the conch; but it differs in its conch being compressed laterally, and in having a strongly contracted aperture of dumbbell shape.

67. **Peismoceras** Hyatt

Plate XLI, figs. 1 A–D

Genotype: *Trochoceras optatum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 111, pl. 23. See also Hyatt, Proc. Amer. Phil. Soc., vol. 32, 1894, p. 500.

Conch consisting of about one and a half volutions, of which only the more apical part is in contact with any later formed portion of the shell. The coiling is only moderately excentric, the excentricity of the apical part of the conch not equalling half the diameter of the living chamber. The direction of the coiling is dextral. The diameter of the umbilical opening is much less than the diameter of the larger end of the conch. The conch is slightly compressed laterally. The transverse annulations curve strongly downward toward the ventral side of the conch, producing a relatively deep hyponomic sinus. Near the aperture these annulations become weak or obsolete. The surface of the shell is marked by numerous longitudinal striae, parallel to the central axis of the conch. The sutures of the septa rise slightly ventrally. The siphuncle is located close to the ventral wall of the conch, and its segments are cylindrical. From Lochkov, Bohemia; in the Middle Silurian, at Barrande's horizon E.

Peismoceras is distinguished from *Sphyradoceras* by its much smaller asymmetric coiling, its lateral compression, and the ventral location of its siphuncle. It is distinguished from *Systrophoceras* in its lateral compression, the ventral location of its siphuncle, the prominence of its transverse annulations ventrally, and the presence of only longitudinal striae, ventrally as well as dorsally.

68. **Systrophoceras** Hyatt

Plate XLI, figs. 2 A–D

Genotype: *Trochoceras arietinum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 103, pls. 17, 25, 103. See also Hyatt, Proc. Amer. Phil. Soc., vol. 32, 1894, p. 502.

Conch almost gyroceran in its form of coiling, slightly asymmetric, possibly similar to *Peismoceras* in this respect, but with a much larger umbilical opening. Apparently the length of the conch scarcely equalled two volutions. There is no trace of contact between these volutions. The direction of its coiling is dextral. Its rate of enlargement is small. Its cross-section is depressed dorso-ventrally, the ventral side being distinctly, though moderately, flattened. The sutures of the septa curve slightly downward laterally, and rise slightly ventrally. The siphuncle is located slightly ventrad of the center of the conch. The transverse annulations curve strongly downward from the dorsal toward the ventral side of the conch, indicating a relatively deep and somewhat angular hyponomic sinus. Along the median part of the ventral side of the conch these annulations become faint. Moreover, here there are traces of faint transverse striae, parallel to the downward curving annulations, while dorsally only striae parallel to the length of the conch are in evidence. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E.

In the closely related species, *Trochoceras pingue* Barrande, the segments of the siphuncle enlarge slightly in a subfusiform manner within the camerae.

Systrophoceras is distinguished from typical *Sphyradoceras* by the more open coiling of the conch, the distinct flattening of its ventral side, the location of the siphuncle slightly ventrad of the center of the conch, the presence of transverse striae along the median part of its ventral side, and the presence of longitudinal striae only along its dorsal side.

69. **Sphyradoceras** Hyatt

Plate XLI, figs. 3 A–D

Genotype: *Trochoceras Clio* Hall, Pal. New York, vol. 5, pt. 2, 1879, p. 392, pls. 59, 111. See also Proc. Boston Soc. Nat. Hist., vol. 22, 1894, p. 298.

Conch trochoceroid, apparently consisting of two and a quarter volutions, coiled in a sinistral direction. The ventral side forms the exterior, convex portion of the volutions, its median part being slightly above mid-height of the whorl when the conch is laid on its side, in a position similar to that of a gasteropod with its umbilical side facing downward. In this position of the conch the earlier formed part of each volution rests upon the upper inner edge of the larger and later formed part of the volution immediately beneath, there being a narrow longitudinal impressed zone here. This lifts the half volution immediately preceding the last volution distinctly above the level of the living chamber though leaving the more apicad part of the spire relatively flat, and sloping downward in a direction away from the living chamber. The umbilical opening on the lower face of the conch has a diameter of at least 5 mm., and this opening continues undiminished in diameter through the apicad part of the spire. The inner or concave wall of the last volution slopes outward toward its base. At the base of the living chamber the cross-section of the conch is slightly depressed dorso-ventrally. The phragmacone is distinctly annulated, the annulations being almost directly transverse along the upper face of the volutions to a point slightly above mid-height of the individual whorls, but below this level they are directed downward and backward as far as the median part of the lower face of the whorls. The sutures of the septa curve slightly farther forward, or toward the aperture, along the median part of the ventral side of the conch than do the annulations. Along the living chamber the annulations are nearly obsolete but are distinctly more numerous. In addition to the annulations there are relatively faint transverse lines of growth, and more distinct longitudinal or revolving raised lines, about 5 in a width of 3 mm. The siphuncle is located at the center of the

conch. According to Hall, its segments probably were moniliform in outline, but this needs verification. No converging vertical lamellae are present. From Schoharie, New York; in the Schoharie member at the base of the Middle Devonian.

70. **Trochodictyoceras** Gen. nov.

Plate XLIII, figs. 1 A, B

Genotype: *Trochodictyoceras slocomi* Foerste.

Conch apparently consisting of less than two volutions. These are loosely coiled with an umbilical opening of about 12 mm. The apical part of the conch apparently was in contact with the later formed part, but there is no trace of a contact groove. The excentricity of the coiling of the conch is less than half the diameter of the living chamber from its plane of symmetry. The cross-section is nearly circular. The sutures of the septa are directly transverse. The location of the siphuncle is unknown. The cast of the interior of the conch is marked by prominent transverse annulations or ribs which curve strongly downward ventrally, forming a deep V-shaped hyponomic sinus. These annulations or ribs are prominent also on the exterior of the shell, but here there also are prominent longitudinal ridges, spaced at moderately narrower intervals than the transverse ribs, but of almost equal prominence. These longitudinal ribs are present along the earlier half of the last volution, where the shell is preserved, but are not known to be present along the later half of this volution, where the shell is absent, although it is assumed that they were present on the exterior of the shell here also. From Stony Island, Illinois, in the Chicago area; in the Racine member of the Middle Silurian. Collected by Ellsworth E. Hoffstadt, Stony Island, Specimen No. 25553, Walker Museum, Chicago University.

Trochodictyoceras is based upon the character of the ornamentation of the exterior of the shell. Structurally, it is similar to *Lechritrochoceras*, unless there are differences in the location and structure of the siphuncle at present not suspected.

71. **Leurotrochoceras** Gen. nov.

Plate XLIII, figs. 6 A, B

Genotype: *Trochoceras Aeneas* Hall, 20th Rept. New York State Cab. Nat. Hist., 1868, pl. 25, fig. 16, foot-note.

Conch probably consisting of less than two volutions. In case of the type specimen, the phragmacone includes one and a quarter volutions, and that part of the living chamber remaining equals nearly one-third of a volution. Only the apical part of the conch, for a length of about 5 mm., appears to have been in contact with the concave dorsal side of the following volution. This apical part of the conch is only faintly asymmetrical in location, being almost imperceptibly nearer the right lateral wall of the conch, thus making its direction of coiling sinistral. The living chamber, though free from the earlier formed part of the conch, does not diverge more than 2 mm. from the latter. The cross-section of the conch is strongly flattened laterally, especially toward the upper part of the phragmacone and the living chamber. Its ventral side is more narrowly rounded than its dorsal one. The sutures of the septa curve strongly downward laterally and rise higher ventrally than dorsally. The transverse annulations or ribs curve increasingly downward toward the ventral side of the conch. They are most prominent along the ventral side of the conch and become less prominent along its lateral sides, being faint dorso-laterally, and almost obsolete dorsally, especially toward the upper part of the conch. No trace of surface striae, either transverse or longitudinal, is present on that part of the apical end of the conch which is represented by a cast of its exterior. The location of the siphuncle is slightly ventrad of the center, and its segments are cylindrical. From Lyons, Iowa in the Racine member of the Middle Silurian. Specimen No. 2129, American Museum of Natural History. Plate XLIII, figs. 6 A, B.

A closely similar form, with the transverse annulations distinct only along the median part of the ventral side, occurs at about the same horizon at Port Byron, Illinois. In this form the transverse annulations become almost entirely obsolete along the

lateral sides of the phragmacone, and along the living chamber they disappear not only laterally but even ventrally. These living chambers, however, were in direct contact with the ventral side of the preceding volution. Their dorsal side is distinctly impressed, along a line slightly toward the right of the plane of symmetry of the chamber, and the bottom of this impressed zone is indented by the crests of the annulations which were located along the median part of the ventral side of the preceding volution.

Leurotrochoceras is similar to *Catyrephoceras* in its lateral compression, and in the location of its siphuncle slightly ventrad of the center of the conch, but its living chamber does not uncoil conspicuously from contact with the remainder of the conch. On the contrary, it is only slightly separated from the latter or may even be in actual contact in some specimens. Moreover, the annulations, instead of becoming feeble along the ventral side of the conch, are more strongly developed here than along the lateral sides of the conch.

XV. SMOOTH TROCHOCEROIDS WITH NUMMULOIDAL SIPHUNCLES

The smooth trochoceroids include the genera *Oxygonioceras*, *Mitroceras*, and *Foersteoceras*. In all of these genera the structure of the siphuncle is nummuloidal. In *Oxygonioceras* the spire is almost flat; and the ventral margin of the conch is acute. *Goniotrochoceras twenhofeli*, from the Vaurial formation of Anticosti, presents a similar cross-section and lengthwise curvature, but the upper face of the conch, when oriented like a spire, is transversely ribbed, and there are also longitudinal raised lines on both faces. Nothing is known of the location or structure of its siphuncle.

The genera *Mitroceras* and *Foersteoceras* are closely related, but there is a distinct impressed zone in the latter, with an upper shoulder. (Rudemann, New York State Museum Bull. No. 265, 1925, pp. 61–66, pls. 17, 19, 20, 21).

72. **Oxygonioceras** Foerste

Plate XLII, figs. 1 A–E

Genotype: *Trochoceras oxynotum*, Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 91, pl. 14, figs. 1–11. See also Foerste, Denison Univ. Bull., vol. 21, 1925, p. 62.

Conch only slightly asymmetric in its form of coiling, the direction of its coiling being dextral. Successive volutions evidently overlapped, but there is no trace of contact between these volutions. Cross-section of conch laterally compressed, ovate in outline, with the ventral side acute and the dorsal side narrowly rounded. The sutures of the septa curve downward laterally and strongly upward ventrally, forming tall ventral saddles. Siphuncle close to the ventral wall of the conch but not in actual contact with the same. The segments of the siphuncle are obliquely nummuloidal, more or less scalariform in arrangement, with greatly contracted septal necks. The surface of the shell is traversed by obscure transverse lines of growth, which curve downward ventrally, indicating an angular hyponomic sinus. From Kozorz, Bohemia; in the Middle Silurian, at Barrande's horizon E. Plate XLII, figs. 1 A–E.

Lituites tortuosus Sowerby (in Murchison, Silurian System, 1839, p. 622, pl. 11, figs. 3; also Blake, British Fossil Cephalopoda, 1882, p. 221, pl. 31, figs. 3, 3 A) evidently is congeneric, but the cross-section is more cuneate, the camerae relatively are less numerous, and the siphuncle appears to be smaller. According to Blake, the segments of the siphuncle, in a second specimen of this species, are slightly bulbous in form.

Trochoceras postulatum Barrande (loc. cit., pl. 491) and *Trochoceras priscum* Barrande (loc. cit., pl. 12) are closely similar to *Oxygonioceras oxynotum*, but are less angular along the ventral side of their cross-sections. The former is from Gros-Kuchel, Bohemia; the latter from Kozorz, Bohemia; both from the Middle Silurian at Barrande's horizon E. The latter is from the upper part of that horizon, or e2.

XVI. CURVED CONCHS WITH LATERAL WINGS OR NODES

Hyatt included in his Hercoceratidae the genera *Hercoceras, Trochoceras, Ptyssoceras, Ptenoceras,* and *Anomaloceras.* Of these, *Anomaloceras* does not possess either wings or spines.

In *Ptenoceras* there are conspicuous wings with concave upper surfaces at and near the aperture of mature specimens, and the conch is gyroceraconic. In *Trochoceras* there appear to have been similar wings, but the curvature of the conch is trochoceroid. In *Ptyssoceras* the curvature of the conch is cyrtoceroid, and the wings are replaced by lunate lateral ridges, with their concave sides facing upward. In *Hercoceras* the coiling is nautilian and the ornamentation is nodose.

In his Genera of Fossil Cephalopods, and in his Phylogeny of an Acquired Characteristic, Hyatt included the genera *Adelphoceras* and *Triplooceras* in the family Rutoceratidae, but in Zittel-Eastman's Text-book of Paleontology he did not include them in the Ryticeratidae, the changed form in which the preceding family name appeared. In fact, these genera are omitted in the latter publication. Apparently they belong to a distinct family, for which the name *Adelphoceratidae* here is proposed. This family includes also *Homoadelphoceras,* which differs from *Adelphoceras* in the absence of a concave median dorsal zone.

73. **Ptenoceras** Hyatt

Plate XXXIX, figs. 1 A–D

Genotype: *Gyroceras alatum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 162, pls. 44, 103. See also Hyatt, Proc. Amer. Phil. Soc., vol. 32, 1894, p. 491.

Conch gyroceraconic, volutions usually separated by an interval of 2 or 3 mm. Cross-section of individual whorls strongly depressed dorso-ventrally, and transversely elliptical. The transverse striae on the surface of the shell curve only slightly downward along its ventral and dorsal sides, but laterally they curve strongly and rather abruptly downward, forming deep sinuses. At rhythmic intervals there are conspicuous transverse

lines of growth, parallel to the transverse striae. Along the lateral margins of the aperture the latter spreads out into two relatively long and narrow wings which project outward from the conch at right angles to its curving central axis. A similar, but smaller pair of wings is located about 2 cm. beneath the aperture, at the uppermost conspicuous growth-line. The sutures of the septa are nearly directly transverse, or curve slightly downward laterally. The siphuncle is located close to the ventral wall of the conch. Its segments are slightly fusiform in outline, being slightly larger a little above mid-height. Its interior is occupied by converging vertical lamellae. From Konieprus, Bohemia; in the Lower Devonian, at Barrande's horizon f2.

74. **Trochoceras** Barrande

Plate XXXIX, figs. 2 A–D

Genotype: *Trochoceras Davidsoni* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 89, pl. 27.

Conch apparently closely similar to that of *Ptenoceras*, but differing from the latter in its trochoceran form of coiling and in its more or less quadrangular cross-section at later stages of growth. The surface ornamentation of the shell is very similar to that of *Ptenoceras alatum*. The transverse striae curve downward both along the dorsal and the ventral sides of the conch. The lateral side of one of the specimens figured by Barrande (see plate VIII, Fig. 2 B in this bulletin) bears a protuberance which, apparently, is the base of one of the lateral wings, similar to that of the species cited. According to Barrande, there were two pairs of such wings, one at the aperture and one toward the base of the living chamber. The trochoceran form of coiling is by no means conspicuous. The apical end is not sufficiently displaced from a strict plane of symmetry to be on a level with the upper side of the last volution when the conch is oriented like the figure of an ordinary gasteropod. The direction of the coiling is sinistral. The cross-section of the conch is almost circular along the phragmacone, but along the living chamber it becomes more quadrangular. The conch is only slightly de-

pressed dorso-ventrally, the ratio of the dorso-ventral to the lateral diameter being as 5 to 6. The sutures of the septa curve distinctly downward laterally. The siphuncle is in contact with the ventral wall of the conch. Its segments are fusiform in outline, but no converging vertical lamellae have been observed in their interior. From Konieprus, Bohemia; in the Lower Devonian, at Barrande's horizon f2.

It should be noted that the genotypes of *Ptenoceras* and *Trochoceras* came from the same locality and horizon, and that the trochoceran character of the coiling of *Trochoceras* is slight.

75. **Ptyssoceras** Hyatt

Plate XXXIX, figs. 3 A–C

Genotype: *Cyrtoceras alienum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 575, pl. 127.

Conch cyrtoceraconic, strongly curved lengthwise, and depressed dorso-ventrally, especially toward its larger end. The lateral sides of the conch, a little ventrad of their middle line, are marked by short transverse lunate ridges, with their concave margins facing upward. These lunate ridges occur at rhythmic intervals, about 4 in a length equal to the dorso-ventral diameter of the conch. Apparently these lunate transverse ridges are homologous in their origin to the laterally projecting wings of *Ptenoceras* and *Trochoceras*. The sutures of the septa are directly transverse to the curving longitudinal axis of the conch. The siphuncle is located close to the ventral side of the conch. Its segments are cylindroid in vertical outline. No converging vertical lamellae occur in its interior. From Tetin, Bohemia; in the Lower Devonian, at Barrande's horizon g1.

76. **Hercoceras** Barrande

Plate XXXIX, figs. 4 A–E

Genotype: *Hercoceras mirum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 152, pl. 43.

Conch both trochoceroid and nautiloid in curvature. Its

trochoceroid curvature is shown by the location of the apical end of the conch, which departs distinctly from the plane of symmetry of the last half of the last volution, but not sufficiently to be on a level with the upper one of the lateral sides when the conch is oriented like a gasteropod. The direction of curvature of the conch in this position is sinistral, as in *Trochoceras*. The nautiloid character of the coiling is shown by the distinctly impressed zone which extends along the dorsal side of the phragmacone, due to actual contact with the ventral side of the preceding volutions. This impressed zone continues even along the upper part of the living chamber, where this chamber is free from such contact, though here the zone both broadens and weakens. The cross-section of the whorl is strongly depressed dorso-ventrally, the ventro-lateral shoulders being rather prominent, and the lateral faces converging toward the dorsal side of the conch. In old age the trapezoidal cross-section of the conch is reduced to a narrow transverse aperture by the abruptly ventrad curvature of the dorsal margin of this aperture. In consequence, the reduced slit-like aperture faces upward and outward along the ventral side of the living chamber. The sutures of the septa are directly transverse to the curving longitudinal axis of the conch. The siphuncle is close to the ventral wall. Its segments are fusiform in outline. No converging vertical lamellae occur in its interior. The lateral sides of the conch are marked at rhythmic intervals by narrowly lunate projections, similar in location and curvature to those of *Ptyssoceras*, but much smaller in size. At younger stages of growth these projections are located at the ventro-lateral shoulders, but at later stages they are nearer the middle line of these sides, though still ventrad of their exact middle. From Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

77. **Adelphoceras** Barrande

Plate XL, figs. 1 A–C

Genotype: *Adelphoceras Bohemicum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, p. 789, pl. 459.

Conch apparently slightly trochoceroid in its curvature; if so, the direction of its curvature is dextral. The cross-section of the conch is depressed dorso-ventrally, and its dorsal side is not only flattened but distinctly impressed as though by contact with the ventral side of the preceding volution. Actual contact probably took place only at young stages of growth, but the impressed zone continued also at later stages of growth, where the living chamber had become free. The aperture is remarkable in being contracted by the abrupt rectangular infolding of the ventro-lateral sides of the conch. The resulting aperture is stated by Hyatt to be dumb-bell shaped, though Barrande's figures suggest T-shaped apertures, similar to those of *Mandaloceras*, *Hemiphragmoceras*, and *Bolloceras*. The undulations of growth along the dorsal side of the conch are directly transverse, but along the ventro-lateral sides the transverse striae curve increasingly downward, locating the hyponomic sinus along the median part of the ventral side. Along the middle of the ventral sides there is a series of low nodules occurring at rhythmic intervals, and toward the base of the phragmacone there are two additional series of nodules, one ventro-laterally and the other dorso-laterally. The cross-section of the conch is broadly kidney-shaped at its base, varying toward triangular at its top, the maximum lateral diameter being nearer the dorsal side of the conch. The sutures of the septa rise strongly toward the ventral side. The siphuncle is close to this side, and its interior contains converging vertical lamellae. The vertical outline of its segments is unknown. From Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

Adelphoceras bohemicum is regarded by Hyatt (Proc. Amer. Phil. Soc., vol. 32, 1894, p. 519) as closely related to *Triplooceras*, of which *Nautilus insperatus* Barrande is the genotype. This similarity is confined chiefly to the presence of an impressed zone along the dorsal side of the conch and the presence of three rows of low tubercles along its lateral sides.

78. **Homoadelphoceras** Gen. nov.

Plate XL, figs. 2 A, B

Genotype: *Gyroceras devonicans* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 164, pl. 240.

Conch similar to that of *Adelphoceras bohemicum* in its lengthwise curvature, its cross-section, and in the presence of a series of low nodules along the middle of the lateral sides. It differs chiefly in the absence of an impressed zone along the dorsal side and in its symmetrical gyroceran mode of coiling. The lengthwise curvature of the conch is rather abrupt along the lower part of the phragmacone. The cross-section is not as broad laterally. The dorso-lateral and ventro-lateral angulations of this cross-section correspond in location to the dorso-lateral and ventro-lateral series of nodules in *Adelphoceras*, the middle lateral series being distinctly developed in both genera. The sutures of the septa are directly transverse or curve moderately downward ventrally. The siphuncle is near the ventral side of the conch, and its interior is occupied by converging vertical lamellae. From Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

XVII. SMOOTH TROCHOCEROID OR NAUTILOID CONCHS WITH NARROW SIPHUNCLES

These include a heterogeneous group of genera, which are alike in presenting smooth shells with directly transverse sutures of septa, and siphuncles close or in contact with the ventral wall of the conch, their segments being relatively narrow. In *Lorieroceras* and *Anomaloceras* these segments are fusiform in outline; in *Nothoceras* they present concave vertical outlines. *Lorieroceras* is loosely trochoceran, with a tall spire. The other two genera are nautiloid, the cross-section of the conch being strongly depressed dorso-ventrally.

79. **Lorieroceras** Gen. nov.

Plate XL, figs. 3 A–D

Genotype: *Trochoceras Lorieri* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, pt. 3, 1874, p. 682, pl. 460.

Conch *trochoceroid*, forming a loose turbinate spire, whose apical end probably belongs as far above the base of the spire as the length of the lateral diameter of this spire at its base. The coiling is sinistral, and the volutions are not in contact with each other, being 3 mm. apart in the specimen figured. Only a part of the phragmacone is known. The cross-section of the whorls is depressed dorso-ventrally, its maximum depression being several centimeters back from the larger end of the phragmacone. The sutures of the septa are nearly directly transverse, except in the immediate vicinity of the siphuncle where they curve slightly backward. The siphuncle is located in contact with the convex ventral wall of the conch. Its segments are fusiform in outline, but enlarge toward their lower ends, which is unusual in cephalopods. The interior of this siphuncle is occupied by converging vertical lamellae. From Courtoisieres, Sarthe, France, in the Lower Devonian.

80. **Anomaloceras** Hyatt

Plate XL, figs. 4 A–D

Genotype: *Nautilus anomalus* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 151, pl. 34, figs. 3–6. See also Hyatt, Proc. Boston Soc. Nat. Hist., 22, 1884, p. 283; Proc. Am. Phil. Soc., 32, 1894, p. 494, pl. 8, figs. 16–20.

Conch nautiloid, dorsal side impressed by contact with ventral side of preceding volution; about three volutions; cross-section strongly depressed dorso-ventrally. Sutures of septa curving downward ventrally, forming shallow lobes. Siphuncle small, near the ventral wall of the conch; figured in one specimen as though in contact with the latter. Segments of siphuncle cylindroid in outline. Location of siphuncle moderately asym-

metrical, on right side of plane of symmetry. From Hlubocep, Bohemia, in the Middle Devonian, at Barrande's horizon g3.

81. **Nothoceras** Barrande

Plate LIII, figs. 1 A–E

Genotype: *Nothoceras Bohemicum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, 1867, p. 72, pl. 13.

Conch nautiloid, with a broad, though shallow, dorsal impression produced by contact with the preceding volutions. Cross-section of whorls strongly depressed dorso-ventrally, lateral sides rather narrowly rounded. Living chamber fully half a volution in length. Living chamber contracting laterally near its top to an aperture which is much less compressed than the main body of the chamber. Sutures of the septa directly transverse to the curving central axis laterally, but curving slightly forward on approaching the siphuncle ventrally. The siphuncle is in contact with the ventral wall of the conch. The vertical outline of its segments, where not in contact with the conch, is concave, and its interior is occupied by converging vertical lamellae. From Hlubocep, Bohemia; in the Middle Devonian, at Barrande's horizon g3.

PLATE XXXII[23]

Fig. 1. *Laumontoceras laumonti* (Barrande). Vertical section through siphuncle, with converging vertical lamellae at the septal necks. Probably from Nehou, in Manche, France; in the Lower Devonian. Syst. Sil. Boheme, pl. 235, fig. 2; size, 0.94 diameter.

Figs. 2 A,B. *Jovellania buchi* (de Verneuil). A, dorso-ventral section through siphuncle with vertical lamellae. B, septum viewed from beneath, with converging arrangement of vertical lamellae. Nehou, Manche, France; Lower Devonian. Bayle, in Explication de la Carte Geol. de France, vol. 4, Atlas, 1878, pl. 35, figs. 2, 3.

Figs. 3 A–D. *Mixosiphonoceras desolatum* (Barrande). A, ventral side; B, broken septa viewed from beneath, with converging vertical lamellae; C, lateral view; D, dorso-ventral section through siphuncle. Bohemia, probably from Dvoretz; Middle Silurian. Syst. Sil. Boheme, pl. 513, figs. 3, 4, 1, 2; size, 0.63 diameter.

Figs. 4 A–D. *Tripleuroceras archiaci* (Barrande). A, ventral side, with siphuncle exposed by weathering. B, septa viewed from beneath, siphuncle with converging vertical lamellae. C, dorso-ventral section through siphuncle. D, lateral view of siphuncle. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 251, figs. 1, 3, 2, 5; size, 0.45 diameter.

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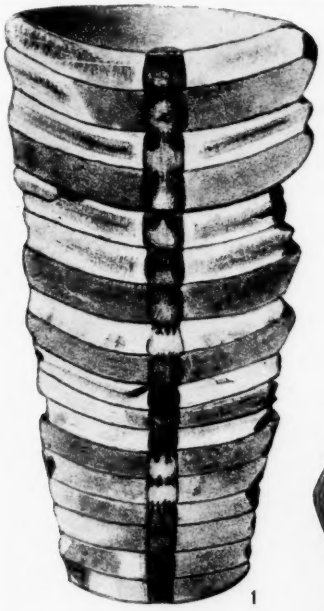
[23] In the following descriptions of plates, the original numbers and letters of the figures here reproduced are cited in the order in which they are lettered on the present plates. In the case of the Barrande figures, the amount of reduction in size in the present publication is indicated.



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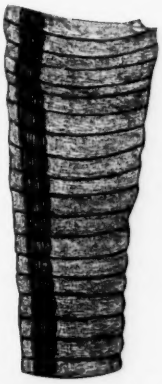

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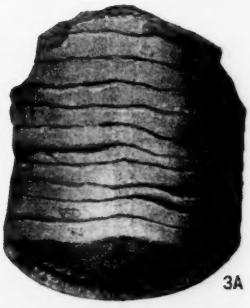


3A

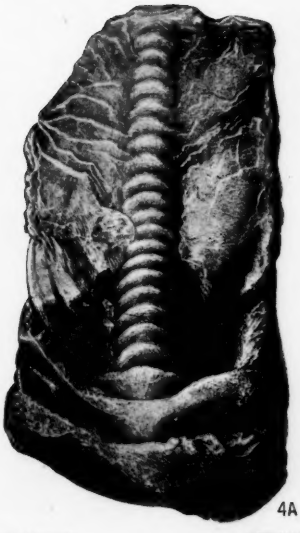
3B

2B

4D

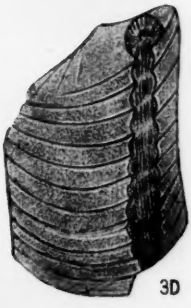
4C

3C



4A

4B



3D

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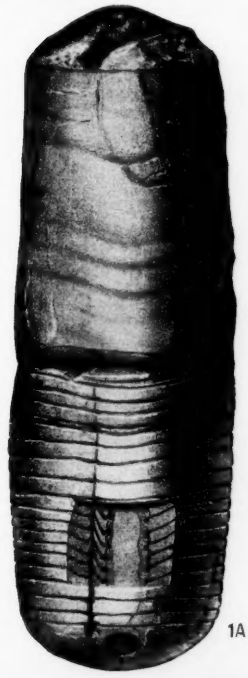
PLATE XXXIII

Figs. 1 A–C. *Projovellania athleta* (Barrande). A, ventral side, cut near the base in order to expose the siphuncle; B, lateral view; C, septum viewed from beneath. Dvoretz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 510, figs. 10, 9, 11; size, 0.65 diameter.

Figs. 2 A, B. *Tripleuroceras triangulare* (d'Archiac and de Verneuil). A, dorsal view; B, septum viewed from beneath. Wissenbach, Germany; Middle Devonian. Trans. Geol. Soc. London, ser. 2, vol. 6, 1842, pl. 27, figs. 1, 1a.

Figs. 3 A–C. *Tripleuroceras roemeri* Foerste. A, ventral view; B, dorsal view; C, septum viewed from beneath, with converging vertical lamellae. Gosslar, Germany; Middle Devonian. Beiträge zur geol. Kenntniss des nordwestlichen Harzgebirges, 1850, pt. 5, pl. 1, figs. 2b, a, c.



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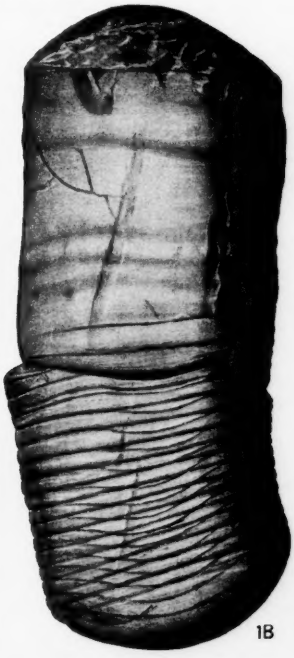

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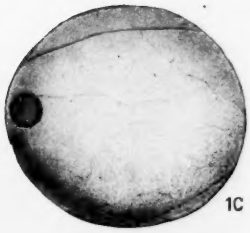
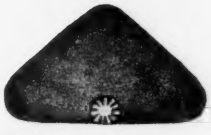


1C

2A

2B



3C

3B

3A

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ACTINOSIPHONATE AND TROCHOCERQID CEPHALOPODS

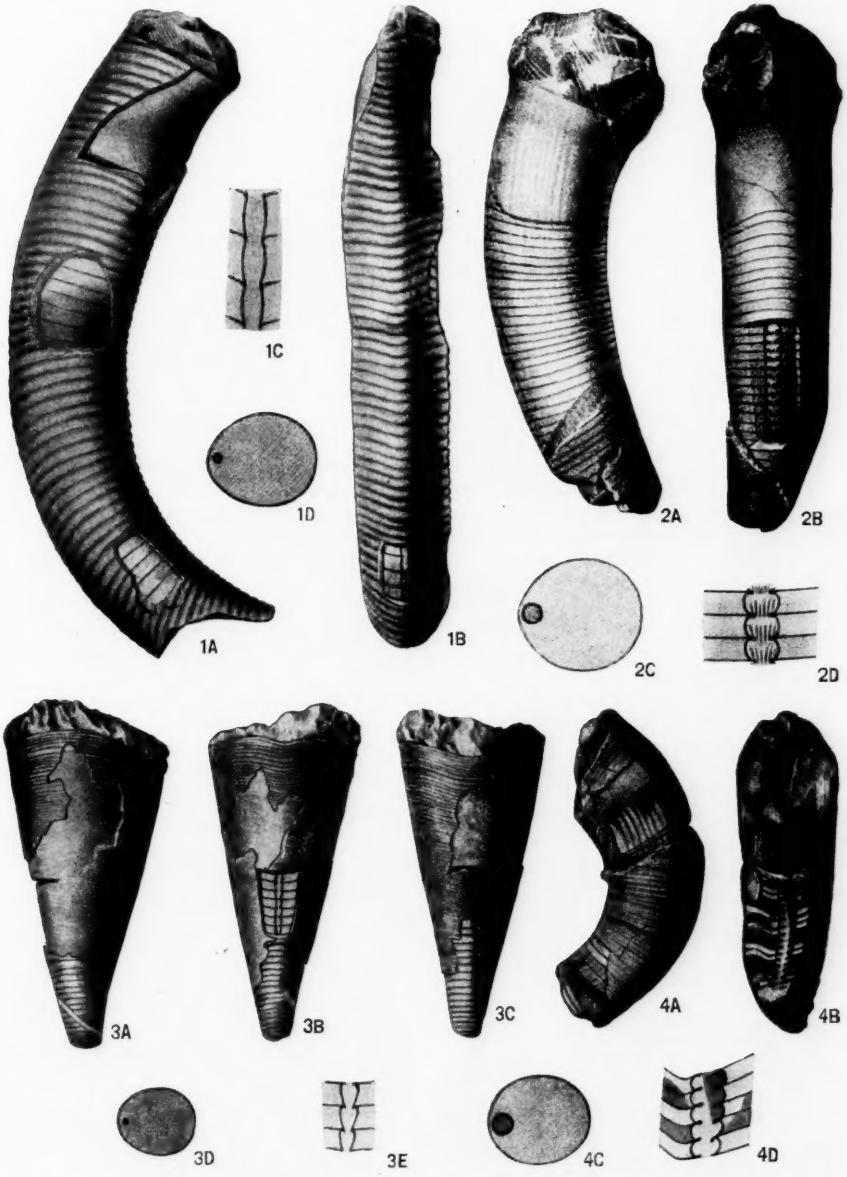
PLATE XXXIV

Figs. 1 A–D. *Oonoceras acinaces* (Barrande). A, lateral view, showing height of living chamber; B, ventral view, showing siphuncle at base; C, vertical section through siphuncle; D, cross-section showing siphuncle. Dlauha-Hora, Bohemia: Middle Silurian. Syst. Sil. Boheme, pl. 118, figs. 9, 10, 14, 12; size, 0.65 diameter.

Figs. 2 A–D. *Oocerina lentigradum* (Barrande). A, lateral view, showing height of living chamber; B, ventral view, showing siphuncle in lower half; C, cross-section; D, vertical section through siphuncle showing converging vertical lamellae. Lochkov, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 137, figs. 1, 2, 4, 5; size 0.87 diameter.

Figs. 3 A–E. *Rizoceras indocile* (Barrande). A, lateral view, with ventral side on left; B, ventral view showing height of living chamber and upper part of siphuncle; C, dorsal view; D, cross-section; E, vertical section through siphuncle. Kozorz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 185, figs. 1, 2, 3, 4, 5.

Figs. 4 A–D. *Endoplectoceras secula* (Barrande). A, lateral view with ventral side on left; B, ventral view; C, cross-section: D, vertical section through siphuncle. Vallon de Slivenetz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 510, Figs. 1, 2, 3, 4.



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ACTINOSIPHONATE AND TROCHOCERIOID CEPHALOPODS

PLATE XXXV

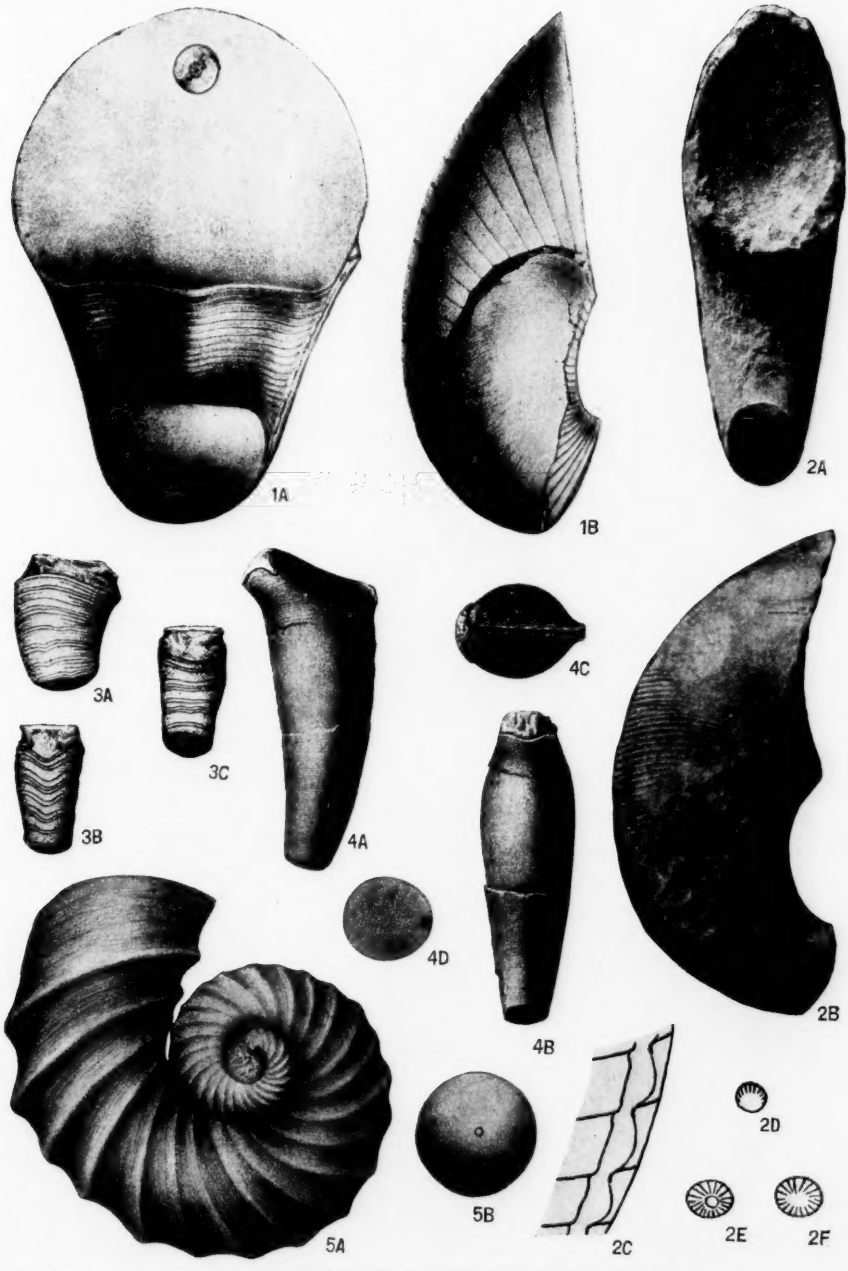
Figs. 1 A,B. *Cyrtoceras depressum* Goldfuss. A, dorsal view, with septum at top and bottom of specimen, the siphuncle showing converging vertical lamellae; B, lateral view of same. Trans. Geol. Soc. London, 2nd ser., vol. 6, pt. 2, 1842, p. 350, pl. 29, figs. 1, 1a.

Figs. 2 A–F. *Karoceras typicum* Foerste. A, dorsal view, with septum at top and bottom, exposing siphuncle; B, lateral view of same; C, vertical section through siphuncle; D, cross-section of same, showing converging vertical lamellae; E, F, two cross-sections of siphuncle of another specimen. Nesnayemi Fjord, in strata provisionally regarded as Lower Devonian. Rept. Sci. Results of Norwegian Expedition to Novaya Zemblya, No. 31, 1925, pls. 3, 7.

Figs. 3 A–C. *Cyrtorizoceras minneapolis* Clarke. A, lateral view of living chamber; B, ventral view; C, dorsal view. Minneapolis, Minnesota; Platteville member of Black River; Middle Ordovician. Geol. Minnesota, vol. 3, pt. 2, 1897, pl. 59, figs. 1, 4, 2.

Figs. 4 A–D. *Inversoceras perversum* (Barrande). A, lateral view; B, dorsal view; C, view of aperture from above; D, cross-section showing siphuncle. Kozorz, Bohemia; Middle Silurian. Systeme Sil. Boheme, pl. 53, figs. 1, 2, 4, 5.

Figs. 5 A, B. *Lechritrochoceras desplainense* (McChesney). A, spire viewed from above; B, cross-section showing siphuncle. Racine, Wisconsin; Middle Silurian. 20th Rept. New York St. Cab. Nat. Hist., pl. 16, figs. 8, 10.



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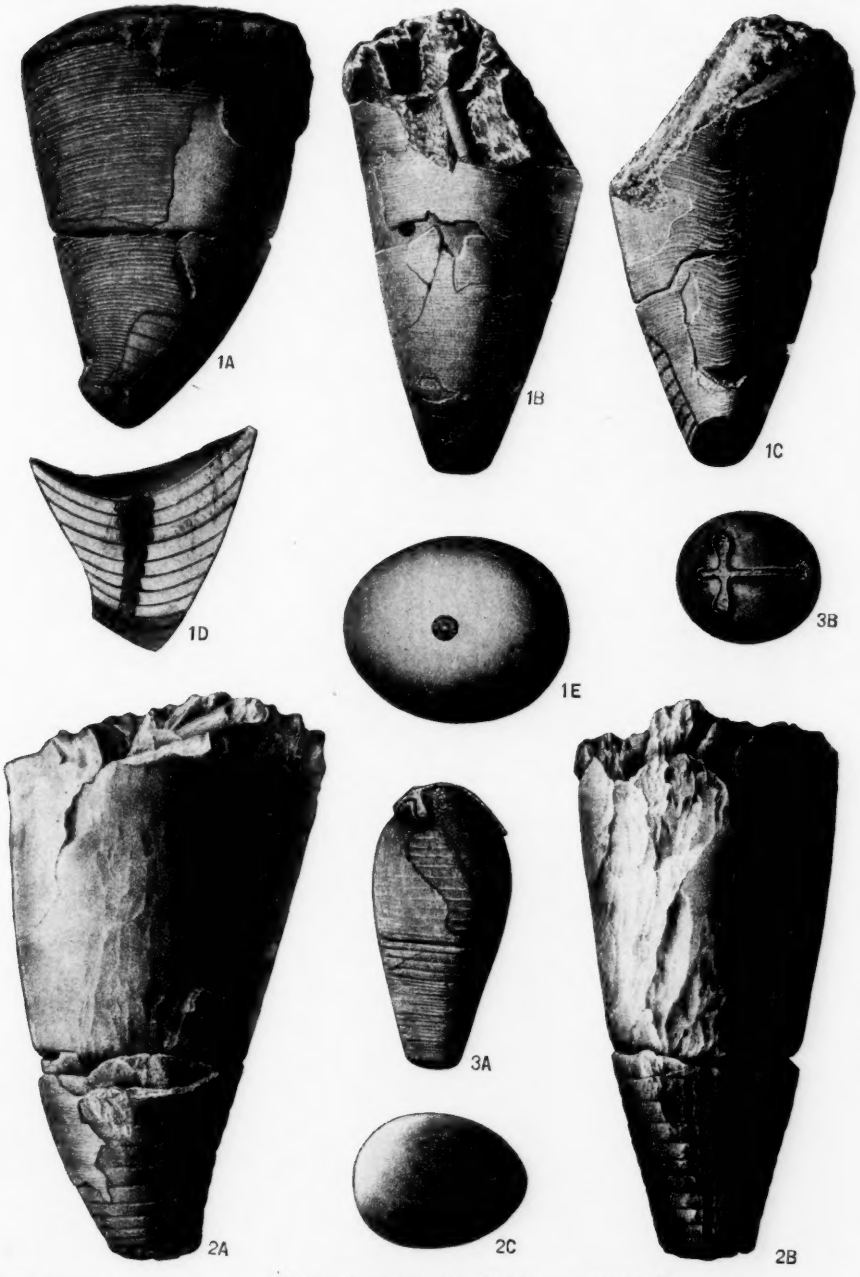
ACTINOSIPHONATE AND TROCHOCEROID CEPHALOPODS

PLATE XXXVI

Figs. 1 A–E. *Codoceras indomitum* (Barrande). A, lateral view with ventral side on left; B, dorsal side; C, ventral side; D, dorso-ventral section through siphuncle showing converging vertical lamellae; E, septum viewed from beneath. Lochkov, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 162, figs. 1, 3, 2, 5, 4; size, 0.63 diameter.

Figs. 2 A–C. *Danaoceras danai* (Barrande). A, lateral view with ventral side on right; B, ventral view showing siphuncle with converging vertical lamellae; C, septum viewed from beneath. Kozorz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 171, figs. 6, 7, 8; size, 0.61 diameter.

Figs. 3 A, B. *Trimeroceras staurostoma* (Barrande). A, lateral view with ventral side on right; B, view of living chamber from above, showing aperture. Kozorz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 73, figs. 3, 2.



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ACTINOSIPHONATE AND TROCHOCEROID CEPHALOPODS

PLATE XXXVII

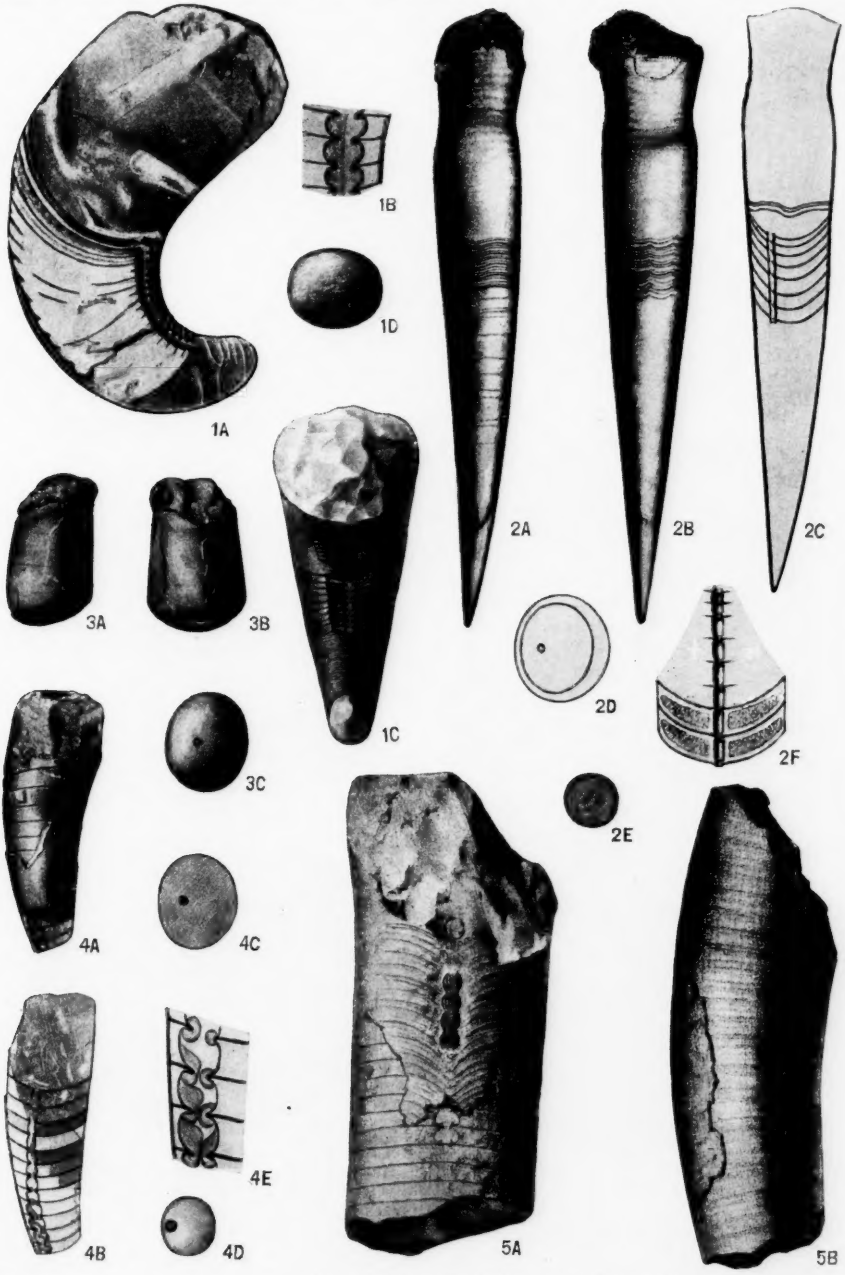
Figs. 1 A–D. *Protophragmoceras murchisoni* (Barrande). A, dorso-ventral vertical section through siphuncle; B, vertical section through siphuncle; C, ventral view showing siphuncle at upper end of phragmacone; D, septum viewed from beneath. A, B, Dlauha-Hora; C, D, Lochkov, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 176, figs. 11, 12, 9, 10; size, 0.65, except fig. B.

Figs. 2 A–F. *Clinoceras dens* Mascke. A, lateral view, with ventral side on left; B, ventral side; C, dorso-ventral section, with ventral side on left; D, cross-section near top of specimen; E, cross-section near base; F, vertical section showing upper part of siphuncle. Erratic blocks at Königsberg, Prussia, Germany; presumably of Ordovician origin. Zeits. d. Deutschen Geol. Gesellschaft, vol. 28, 1876, pl. 1, figs. 1, a, b, c, d, e.

Figs. 3 A–C. *Cyrtactinoceras rebelle* (Barrande). A, lateral view of living chamber with ventral side on left; B, ventral view; C, septum at base of chamber viewed from beneath. Bubovitz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 164, figs. 11, 10, 12; size, 0.64 diameter.

Figs. 4 A–E. *Cyrtactinoceras rebelle* (Barrande). A, lateral view with ventral side on left and section through siphuncle at base; B, dorso-ventral section through siphuncle; C, cross-section through upper part of specimen; D, cross-section through lower end of specimen; E, dorso-ventral section through lower part of siphuncle. Bubovitz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 164, figs. 5, 7, 6, 8, 9; size, 0.64, except fig. E.

Figs. 5 A, B. *Coelocyrtoceras ventralisinuatum* (Sandberger). A, ventral view showing siphuncle with converging vertical lamellae; B, lateral view with ventral side on right. Wissenbach, Germany; Middle Devonian. Verstein. d. Rhein. Schichtensystems in Nassau, 1850–56, pl. 14, figs. 3a, 3.



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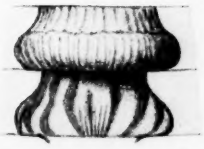
ACTINOSIPHONATE AND TROCHOCEROID CEPHALOPODS

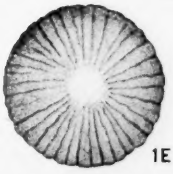
PLATE XXXVIII

Figs. 1 A–E. *Conostichoceras palinurus* (Barrande). A, ventral view, with siphuncle; B, lateral view with ventral side on right: C, septum viewed from beneath; D, two segments of siphuncle, one with calcareous deposit of interior viewed from side, the other sectioned vertically; E, cross-section of latter. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 466, fig. 1; pl. 467, fig. 1; pl. 466, figs. 2, 4, 3. Size of A, B, 0.60 diameter; size of C, 0.92 diameter.

1A

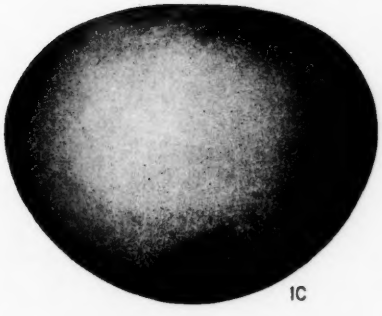


1D



1E

1B



1C

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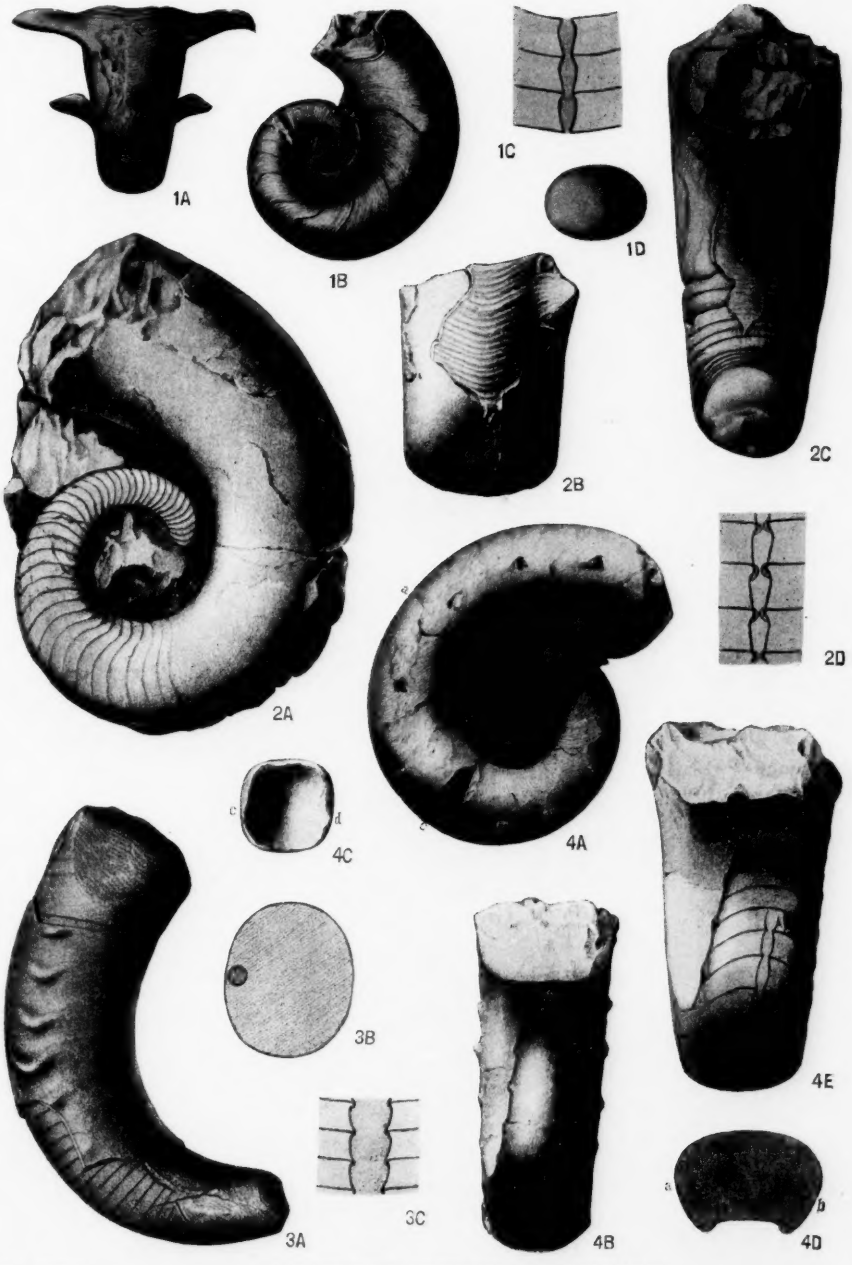
PLATE XXXIX

Figs. 1 A–D. *Ptenoceras alatum* (Barrande). A, ventral side; with lateral wings; B, lateral view, with rhythmically spaced growth lines of which the last two, at later stages of growth, develop into lateral wings; C, vertical section through siphuncle; D, septum viewed from beneath. Konieprus, Bohemia; Lower Devonian. Syst. Sil. Boheme, pl. 44, figs. 9, 10, 15, 13, each figure from a different specimen. Size of fig. A, 0.54; of figs. B, D, 0.63.

Figs. 2 A–D. *Trochoceras davidsoni* Barrande. A, lateral view with siphuncle on convex side. B, ventral side of part of living chamber showing basal part of a horizontally extended wing, similar to that of *Ptenoceras alatum*. C, dorsal view, showing location of siphuncle at base. D, vertical section through siphuncle with calcareous deposits lining inner margin of the septal necks. Konieprus, Bohemia; Lower Devonian. Syst. Sil. Boheme, pl. 27, figs. 4, 5, 2, 7, each from a different specimen. Size, 0.65 diameter.

Figs. 3 A–C. *Ptyssoceras alienum* (Barrande). A, lateral view, with short lateral ridges corresponding apparently to the lateral wings of the two preceding genera; ventral side on left. B, cross-section. C, vertical section through siphuncle. Tetin, Bohemia; Lower Devonian. Syst. Sil. Boheme, pl. 127, figs. 1, 3, 4; size, 0.90 diameter.

Figs. 4 A–E. *Hercoceras mirum* Barrande. A, lateral view, with short tubercular projections at rhythmic intervals apparently corresponding to the short lateral ridges of *Ptyssoceras;* lower part of aperture closed at gerontic stage by ascending dorsal wall. B, conch viewed from smaller side of last volution, showing upward curvature of dorsal wall of aperture. C, septum viewed from above, located at point *c* in figure A. D, cross-section at *a* in figure A. E, last volution of another specimen showing the location of the siphuncle. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 43, figs. 1, 2, 4, 3, 6; size, 0.65 diameter.



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ACTINOSIPHONATE AND TROCHOCERIOID CEPHALOPODS

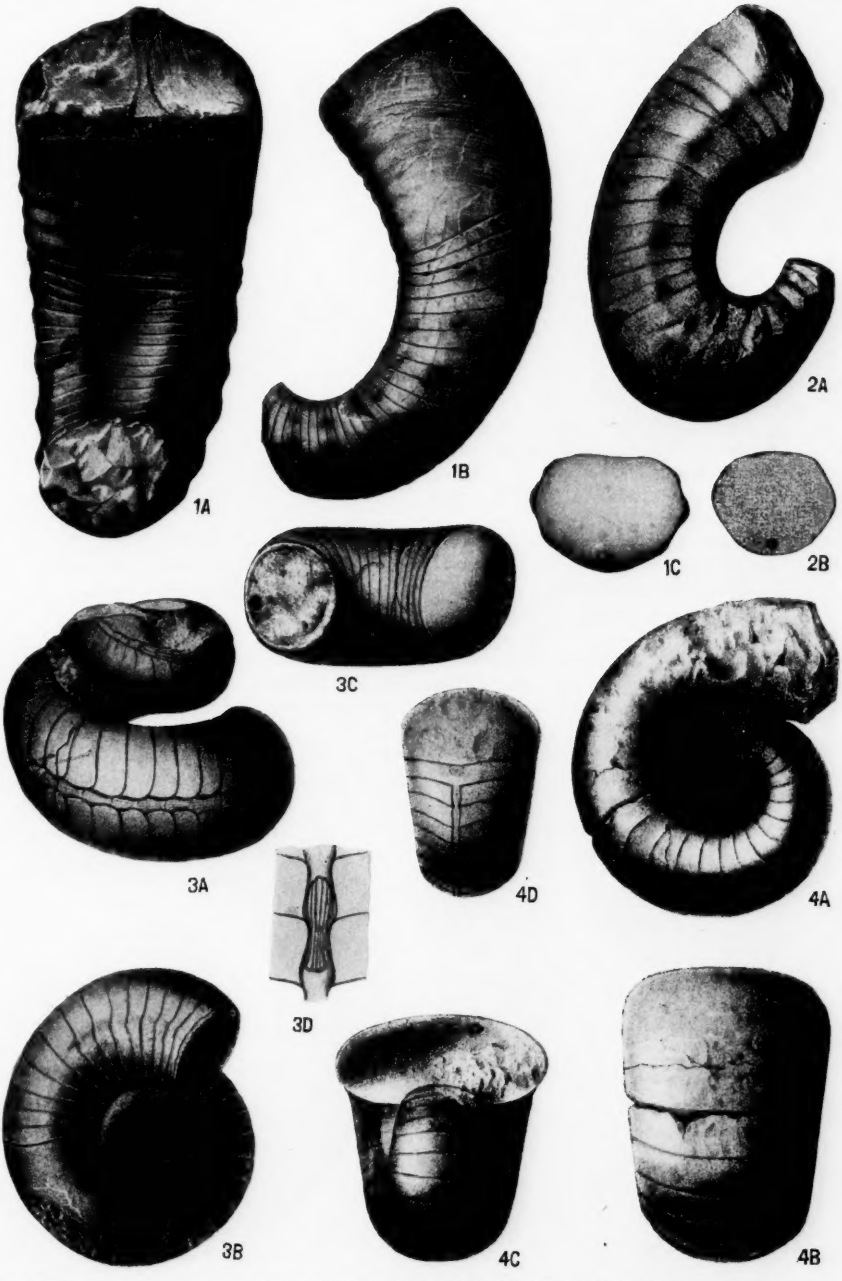
PLATE XL

Figs. 1 A–C. *Adelphoceras bohemicum* Barrande. A, ventral side of conch, showing outline of aperture. B, lateral view with longitudinal rows of nodules; showing flattened top of conch at aperture. C, cross-section showing location of three rows of low nodules. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 459, figs. 2, 1, 5; size, 0.47.

Figs. 2 A–B. *Homoadelphoceras devonicans* (Barrande). A, lateral view, with nodules. B, cross-section, without an impressed dorsal zone. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 240, figs. 16, 17; size of A, 0.46 of B, 0.80 diameter.

Figs. 3 A–D. *Lorieroceras lorieri* (Barrande). A, lateral view of spire showing siphuncle. B, umbilical view of spire. C, dorsal view of phragmacone. D, vertical section showing siphuncle whose interior is occupied by converging vertical lamellae. Courtoisieres, Department de la Sarthe, France; Lower Devonian. Syst. Sil. Boheme; pl. 460, figs. 13, 14, 15, 16; size 0.67 diameter.

Figs. 4 A–D. *Anomaloceras anomalum* (Barrande). A, lateral view, dorsal side with impressed zone; B, convex ventral side; C, view of last volution from its smaller side, showing location of siphuncle; D, ventral side of another specimen, showing siphuncle. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 34, figs, 3, 4, 5, 6; size, 0.65 diameter.



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ACTINOSIPHONATE AND TROCHOCEROID CEPHALOPODS

PLATE XLI

Figs. 1 A–D. *Peismoceras optatum* (Barrande). A, lateral view, spire dextral. B, viewed to show smaller end of last volution and outline of aperture. C, dorsal view of another specimen. D, ventral view of latter, showing siphuncle. Lochkov, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 23, figs. 6, 7, 8, 9; size 0.65 diameter.

Figs. 2 A–D. *Systrophoceras arietinum* (Barrande). A, lateral view. B, dorsal view, with vertical raised lines on this side only. C, ventral view, with oblique annulations weak along middle of this side. D, cross-section, oriented as in figure A. Kozorz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 17, figs. 1, 2, 3, 4; size, 0.72 diameter.

Figs. 3 A–. *Sphyradoceras clio* (Hall). A, umbilical view, with longitudinal raised lines, and transverse annulations. B, profile view of A, showing course of annulations and of sutures of septa along smaller end of specimen. C, concave dorsal or umbilical side of conch, showing septum and position of siphuncle. D, height of spire, with plane of the more apicad volution sloping downward toward the observer. Schoharie, New York; in the Schoharie grit member at the base of the Middle Devonian. Pal. New York, vol. 5, pt. 2, pl. 59, figs. 2, 3, 4, 5; size, 0.75 diameter.

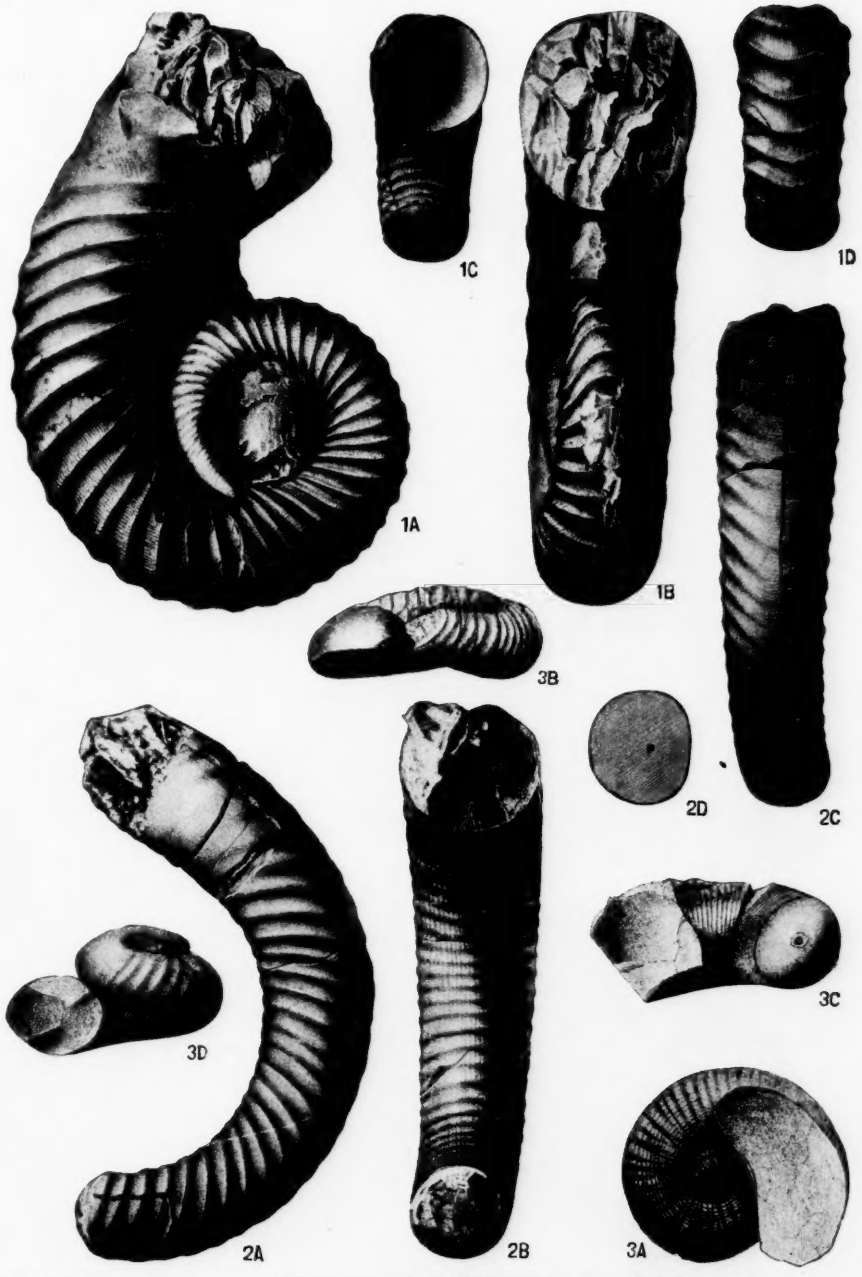

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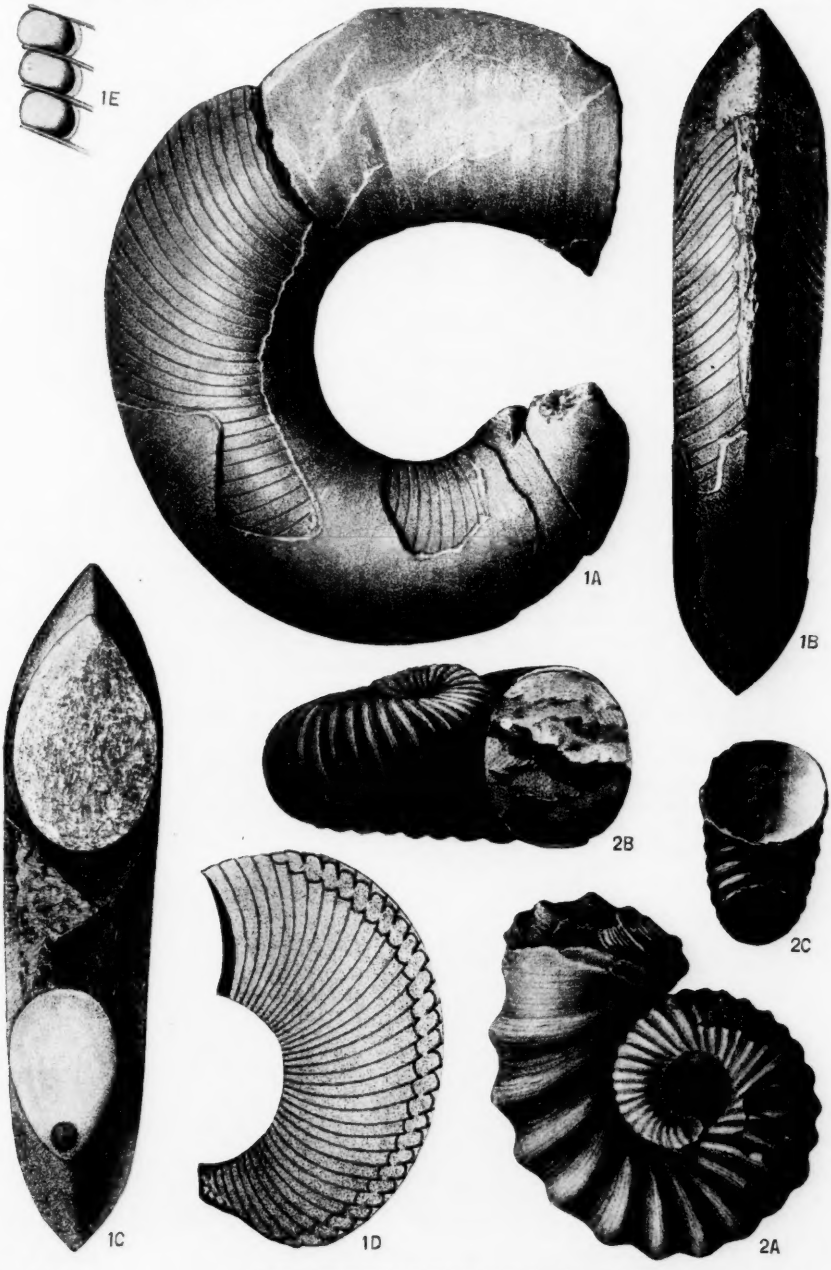
PLATE XLII

Figs. 1 A–E. *Oxygonioceras oxynotum* (Barrande). A, lateral view, showing length of living chamber. B, ventral side of same specimen. C, dorsal side of same specimen, showing outline of aperture at top, and location of siphuncle at lower end. D, dorso-ventral section through another specimen, showing structure of siphuncle. E, lateral view of 3 segments of siphuncle of another specimen. A, B, C, D, from Lochkov; E, from Hinter Kopanina, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 14, figs. 9, 10, 11, 8, 7; size of A, B, C, 0.95 diameter; of D, E, same as in Barrande.

Figs. 2 A–C. *Lechritrochoceras* (?) *placidum* (Barrande). A, lateral view from apical side of conch, with dextral curvature. B, profile view of spire, showing cross section of conch near aperture. C, dorsal side of fragment, showing location of siphuncle. Butovitz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 23, figs. 1, 2, 3; size, of A, B, same; of C, 0.70 diameter.



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ACTINOSIPHONATE AND TROCHOCEROID CEPHALOPODS

PLATE XLIII

Figs. 1 A, B. *Trochodictyoceras slocomi* Foerste. A, ventral view of cast of interior of conch; B, upper view of spire of same specimen, preserving exterior of shell along apical end. Stony Island, in southern Chicago, Illinois; Racine dolomite. Middle Silurian. No. 25553 Walker Museum, Chicago University.

Fig. 2. *Catyrephoceras giganteum* (Blake). Ventral view of apical end of conch, also showing aperture of living chamber as seen from above. Leintwardine, Great Britain; Lower Ludlow, Middle Silurian. Blake, British Fossil Cephalopoda, 1882, pl. 31, fig. 2. Referred by Blake to same species as *Lituites giganteus* Sowerby, later regarded as a *Trochoceras*.

Figs. 3 A, B. *Archiacoceras subventricosum* Archiac and Verneuil. A, lateral view; B, view of base, showing siphuncle. Refrath, Eifel, Germany; Middle Devonian. Trans. Geol. Soc. London, ser. 2, vol. 6, 1842, pl. 30, figs. 1, 1a.

Fig. 4. *Wetherbyoceras conoidale* Wetherby. Lateral view. Point Leavel, Garrard county, Kentucky. No. 35064, U. S. National Museum.

Fig. 5. *Centrocyrtoceras duplicostatum* (Whitfield). Lateral view. Beloit, Wisconsin; Platteville member of Black River. Specimen No. 70827 U. S. National Museum.

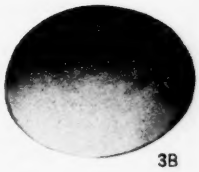
Figs. 6 A–B. *Leurotrochoceras aeneas* (Hall). A, lateral view; B, cross-section, with location of siphuncle as indicated by other specimens. Lyons, Iowa. Original of type figured in 20th Rept. State Cab. Nat. Hist. 1868, pl. 25, fig. 16. From equivalent of Racine, in Middle Silurian. Specimen No. 2129, American Museum of Natural History.

1A

2

3A

1B



3B

4

5

6A

6B

PLATE XLIV

Figs. 1 A–C. *Wissenbachia orthogaster* (Sandberger). A, ventral view; B, lateral view; C, basal camera of fig. A enlarged, showing converging vertical lamellae. Wissenbach, Germany; Middle Devonian. Versteinerungen d. Rhein. Schichtensystems in Nassau, 1850–56, pl. 14, figs. 4, 4a, 4b.

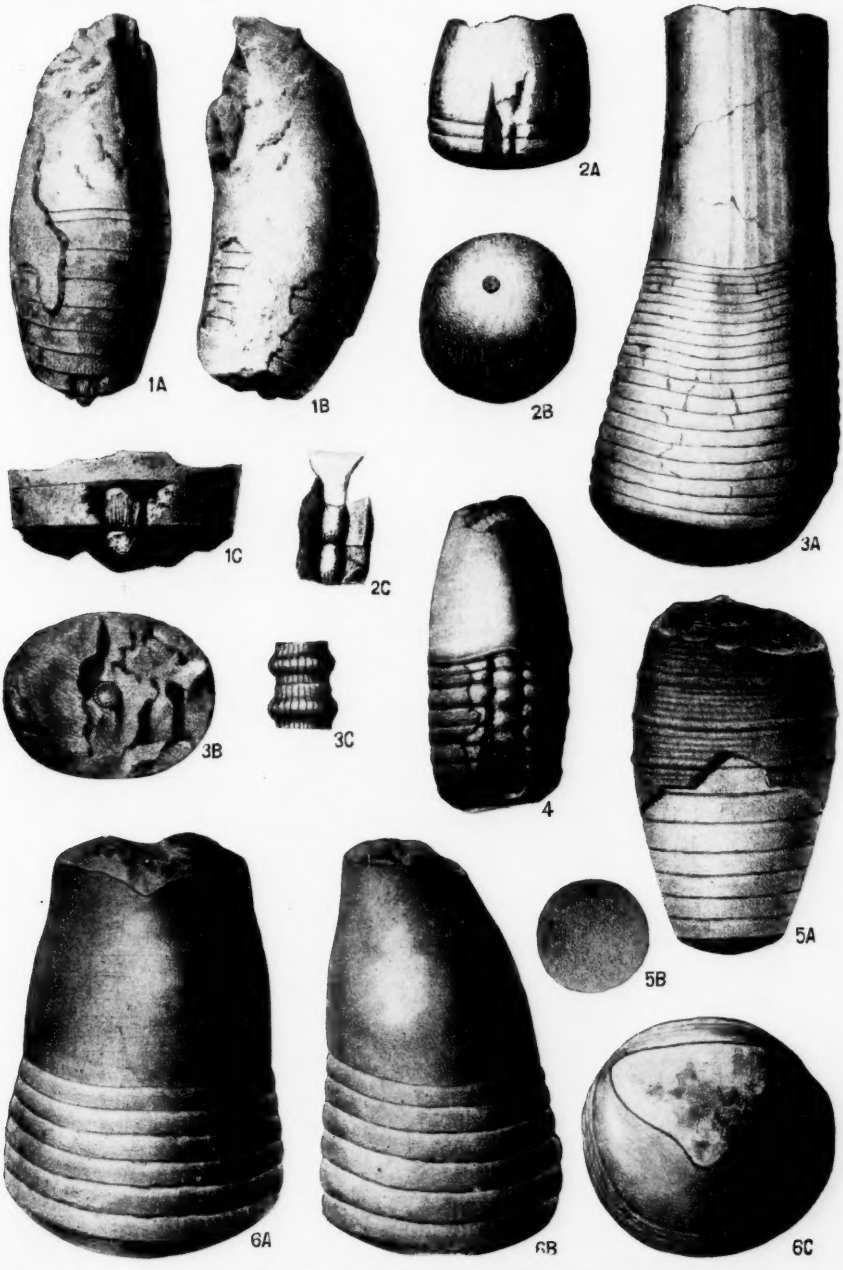
Figs. 2 A–C. *Pachtoceras rotundum* (Pacht). A, ventral side, exposing siphuncle ventrad of center of conch; B, septum viewed from beneath, showing location of siphuncle; C, basal part of fig. A magnified, showing converging vertical lamellae. Gräsi, Upper Don area, Russia; Upper Devonian. Beiträge zur Kenntniss des Russischen Reiches, vol. 21, 1858, pl. 2, figs. 2, 2b, 2a.

Figs. 3 A–C. *Mecynoceras rex* (Pacht). A, lateral view, with the right side possibly ventral. B, cross-section showing siphuncle with converging vertical lamellae. C, two segments of the siphuncle, with annular enlargements at mid-height. Upper Don River area, Russia; Upper Devonian. Beiträge zur Kenntniss des Russischen Reiches, vol. 21, 1858, pl. 1, figs. 1, 2, 4.

Fig. 4. *Pictetoceras eichwaldi* (Verneuil). Ventral view. According to Verneuil the segments of the siphuncle are constricted at mid-height within the camerae. St. Petersburg, Russia; Ordovician. Geol. de la Russie d'europe et des Montagnes de l'Oural, vol. 2, 1845, pl. 24, fig. 9.

Figs. 5 A–B. *Sycoceras ficus* (Roemer). A, ventral view; B, septum showing location of siphuncle. Harz area, Germany; Upper Devonian. Paleontographica, vol. 3, 1854, pl. 6, figs. 1a, b.

Figs. 6 A–C. *Acleistoceras olla* (Saemann). A, ventral view; B, lateral view with ventral side on right; C, conch viewed from above, showing outline of aperture. Columbus, Ohio; Columbus member of Middle Devonian, equivalent to Onondaga of New York. Palaeontographica, vol. 3, 1854, pl. 19, figs. 1a, b, c.



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ACTINOSIPHONATE AND TROCHOCERIOID CEPHALOPODS

PLATE XLV

Figs. 1 A–C. *Poteriocerina lumbosum* (Barrande). A, lateral view, with ventral side on right; B, cross-section at base, showing location of siphuncle; C, vertical section through siphuncle, showing converging vertical lamellae. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 470, figs. 1, 2, 3; size 0.50 diameter.

Fig. 2. *Poteriocerina lumbosum* (Barrande). Second specimen figured by Barrande under the specific name *lumbosum*, but more depressed dorso-ventrally, maximum gibbosity at extreme top of phragmacone, and also broader here laterally. Probably a distinct species. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 464, fig. 1.

Figs. 3 A–C. *Paracleistoceras devonicans* (Barrande). A, lateral view, with ventral side on left; B, cross-section at base, showing location of siphuncle; C, living chamber viewed from above, showing outline of aperture. Hlubocep, Bohemia: Middle Devonian. Syst. Sil. Boheme, pl. 107, figs. 1, 3, 2; size, 0.48 diameter.

Figs. 4 A–C. *Centrocyrtoceras subannulatum* (D'Orbigny). A, lateral view; B, lateral view; C, ventral view magnified in order to show the transverse striae. Middleville, New York; Trenton, Middle Ordovician. Figures from the type series numbered 821 in the American Museum of Natural History, including the originals of figures 5, 4b and 4d on plate 41 of Pal. New York, vol. 1, 1847.

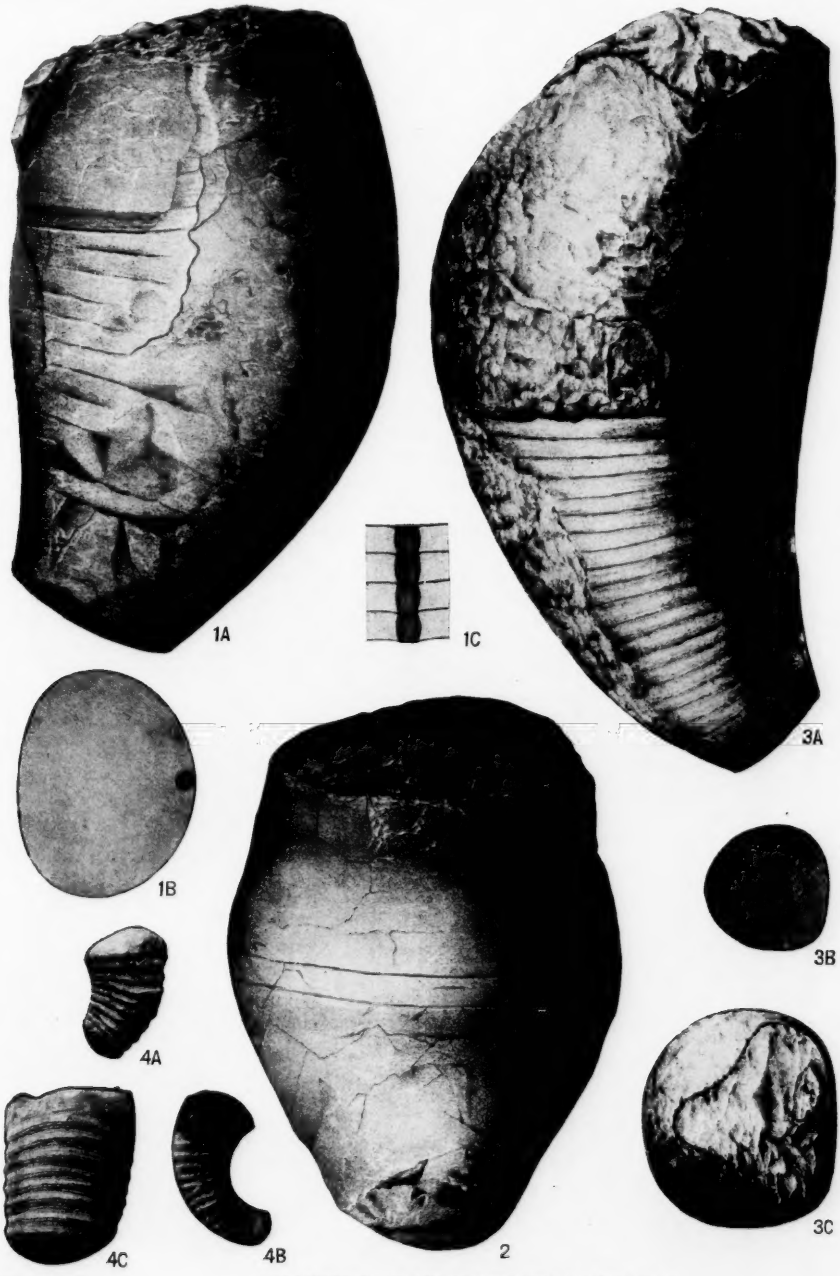

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PLATE XLVI

Figs. 1 A–B. *Cyrtoceras cf. depressum* Bronn. A, dorso-ventral vertical section through siphuncle showing septal necks; walls of camerae lined interiorly with thick calcareous deposit, which outlines also that part of the siphuncle where the connecting rings should be. B, same specimen shaded so as to make the course of the septa more distinct. Interior of siphuncle occupied by converging vertical lamellae. Gerolstein, Eifel, Germany; Middle Devonian. Specimen No. 34047, U. S. National Museum.

Figs. 2 A–B. *Cyrtoceras depressum* Bronn (usually ascribed to Goldfuss). A, dorsal view, showing top of phragmacone with siphuncle containing converging vertical lamellae. B, lateral view, showing high ventral saddles at later stages of growth. Gerolstein, Eifel, Germany; Middle Devonian. Specimen No. 66380, British Museum of Natural History.

Fig. 3. *Poterioceras fusiforme* (Sowerby). Lateral view with ventral side on right. Copied from Foord, Carb. Ceph. Ireland, 1897, pl. 15, fig. 2b. From the Carboniferous.

Figs. 4 A,B. *Poterioceras fusiforme* (Sowerby). A, dorso-ventral vertical section through the siphuncle, with ventral side on left. B, part of section of siphuncle enlarged. Kildare, Ireland; Carboniferous. Specimen No. 2177, Museum of Comparative Zoology, at Harvard University.

1A

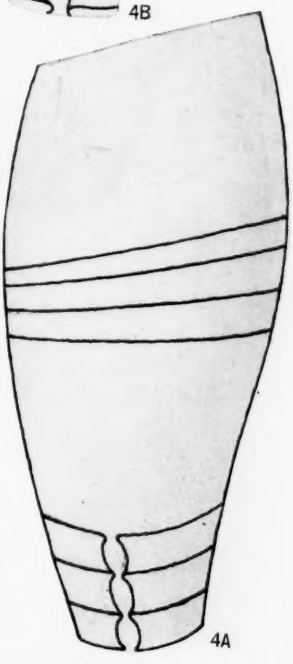
1B

4B

2A

2B

3



4A

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PLATE XLVII

Figs. 1 A–C. *Streptoceras janus* Billings. A, lateral view, showing outward curvature of ventral wall of conch at hyponomic sinus. B, dorsal view. C, outline of aperture copied from Billings, Cat. Sil. Foss. Anticosti, 1866, p. 90. Grimsby, Ontario, Canada; Lockport member of Niagaran, Middle Silurian. Specimen No. 2748, Victoria Memorial Museum.

Figs. 2 A, B. *Amphicyrtoceras orcas* (Hall). A, lateral view; B, ventral view. Waukesha, Wisconsin; in Racine member of Niagaran, Middle Silurian. 20th Rept. New York State Cab. Nat. Hist., 1868, pl. 17, figs. 2, 1; size, 0.77 diameter.

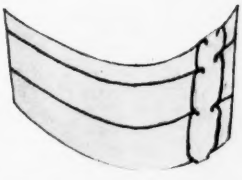
Fig. 3. *Amphicyrtoceras laterale* (Hall). Dorso-ventral section through the siphuncle, showing septal necks and nearly cylindrical lateral walls of segments of siphuncle. Wisconsin; Racine member of Niagaran, Middle Silurian. Specimen No. 634, Public Museum of Milwaukee; size, 0.85 diameter.

1A

1B

1C

2A



3

2B

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PLATE XLVIII

Figs. 1 A, B. *Phragmoceras arcuatum* Sowerby. A, lateral view with hyponomic sinus on right; B, living chamber viewed from above, showing outline of aperture. Dudley, England; Wenlock division of Silurian. From Blake, British Foss. Cephalopoda, 1882, pl. 26, figs. 1, 1a; size, 0.52.

Figs. 2 A–C. *Tubiferoceras proboscideum* Hedström. A, lateral view with tip of lip at hyponomic sinus restored on right. B, another specimen, showing cast of interior of dorsal collar with constriction left by narrow platform at junction of collar with rest of living chamber. C, same specimen viewed from above, showing outline of aperture. Visby, Gotland, Sweden: Middle Silurian. Ueber die Gattung Phragmoceras in der Obersilurformation Gotlands, by Hedström, 1917, pl. 1, figs. 5, 2, 4; size, 0.50 diameter.

Figs. 3 A–C. *Bolloceras rex* (Barrande). A, lateral view, with hyponomic sinus on right. B, living chamber viewed from above. C, septum at base of specimen, showing siphuncle containing converging vertical lamellae. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 62, figs. 1, 4, 3; size, 0.65 diameter.

Figs. 4 A–C. *Hemiphragmoceras pusillum* (Barrande). A, lateral view with hyponomic sinus on right. B, living chamber viewed from above, showing outline of aperture. C, cross-section of conch locating siphuncle. Lochkov, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 52, figs. 1, 4, 5; size same as in Barrande.

Figs. 5 A–C. *Mandaloceras bohemicum* (Barrande). A, lateral view, with ventral side on right; phragmacone sectioned dorso-ventrally and exposing siphuncle. B, living chamber viewed from above, showing outline of aperture. C, septum at base of specimen, locating the siphuncle. Dvoretz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 74, figs. 13, 15, 16; size, 0.65 diameter.

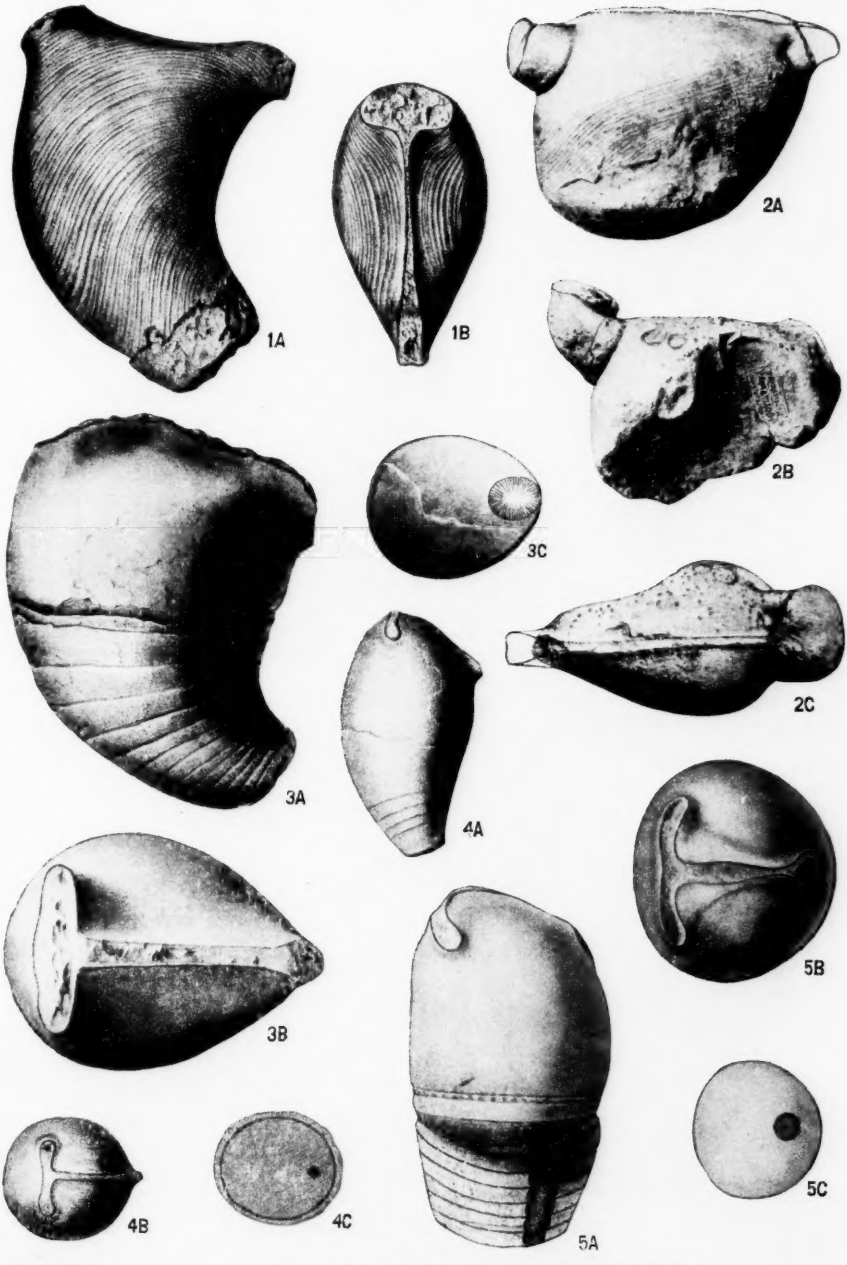

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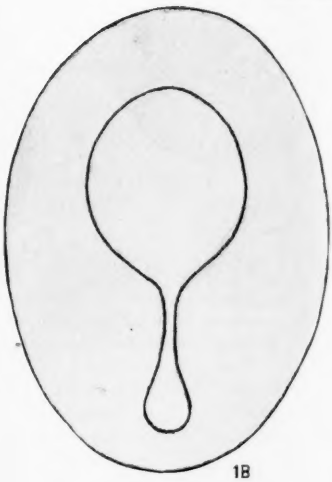
PLATE XLIX

Figs. 1 A, B. *Gomphoceras pyriforme* Sowerby. A, lateral view, with hyponomic sinus at S on left. B, living chamber, viewed from above, showing outline of aperture very dubiously determined. Leintwardine, Great Britain; in Lower Ludlow member of Middle Silurian Side opposite to that represented by figure 2, pl. 22, in Blake, British Fossil Cephalopoda (1882). Nos. 30712, 30713, Museum of Practical Geology. From cast presented by Dr. F. A. Bather, keeper of Department of Geology, British Museum.

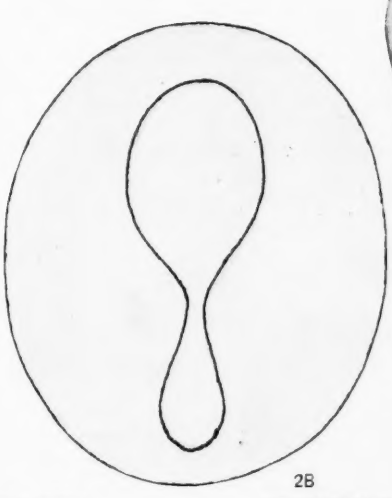
Figs. 2 A, B. *Gomphoceras pyriforme* Sowerby. A, lateral view, with hyponomic sinus on left with the basal part of the lip apparently at the break 8 mm. below the letter S. B, living chamber viewed from above, showing outline of aperture as very dubiously determined. Leintwardine, Great Britain; in Lower Ludlow member of Middle Silurian. Type; Sowerby in Murchison's Silurian System, pl. 8, fig. 19 (upper), 1838. From cast of type presented by Dr. F. A. Bather. No. 6737, in collection of Geological Society of London.

2A



1B

1A



2B

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PLATE L

Figs. 1 A–C. *Tetrameroceras bicinctum* (Barrande). A, lateral view with ventral side on left. B, living chamber viewed from above. C, cross section of conch at base of specimen, showing siphuncle. Viskocilka, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 51, figs. 2, 3, 4; size, 0.90 diameter.

Figs. 2 A–C. *Conradoceras pseudoconradi* Foerste. A, lateral view with ventral side on left. B, living chamber viewed from above, showing outline of aperture. C, cross-section of conch showing siphuncle with converging vertical lamellae. Hinter-Kopanina, Bohemia: Middle Silurian. Syst. Sil. Boheme, pl. 49, figs. 4, 6. 7; size, same as in Barrande.

Figs. 3 A–C. *Hexameroceras panderi* (Barrande). A, lateral view, with ventral side on right. B, living chamber viewed from above, with outline of aperture. C, cross-section of phragmacone showing siphuncle with converging vertical lamellae. Dvoretz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 48, figs. 12, 14, 15; size, 0.65 diameter.

Figs. 4 A–C. *Octameroceras callistomoides* Foerste. A, lateral view, with ventral side on left. B, living chamber viewed from above, showing outline of aperture. C, septum at base of specimen, showing location of siphuncle. St. Procop (?), Bohemia, Middle Silurian. Syst. Sil. Boheme, pl. 67, figs. 3, 4, 7; size, 0.61 diameter.

Figs. 5 A–D. *Paraconradoceras rigescens* (Barrande). A, lateral view, with ventral side on right. B, living chamber from above, showing outline of aperture C, septum showing location of siphuncle, the latter containing converging vertical lamellae. D, vertical section through siphuncle showing concave vertical outlines of segments within the camerae. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 520, figs, 4, 5, 6, 7; size, 0.70 diameter.

Figs. 6 A–C. *Pentameroceras mirum* (Barrande). A, lateral view with ventral side on right. B, living chamber viewed from above, with outline of aperture. C, septum at base of specimen, showing location of siphuncle. Hinter-Kopanina, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 82, figs. 23, 25, 24; size of A, B, magnified 2 diameters.

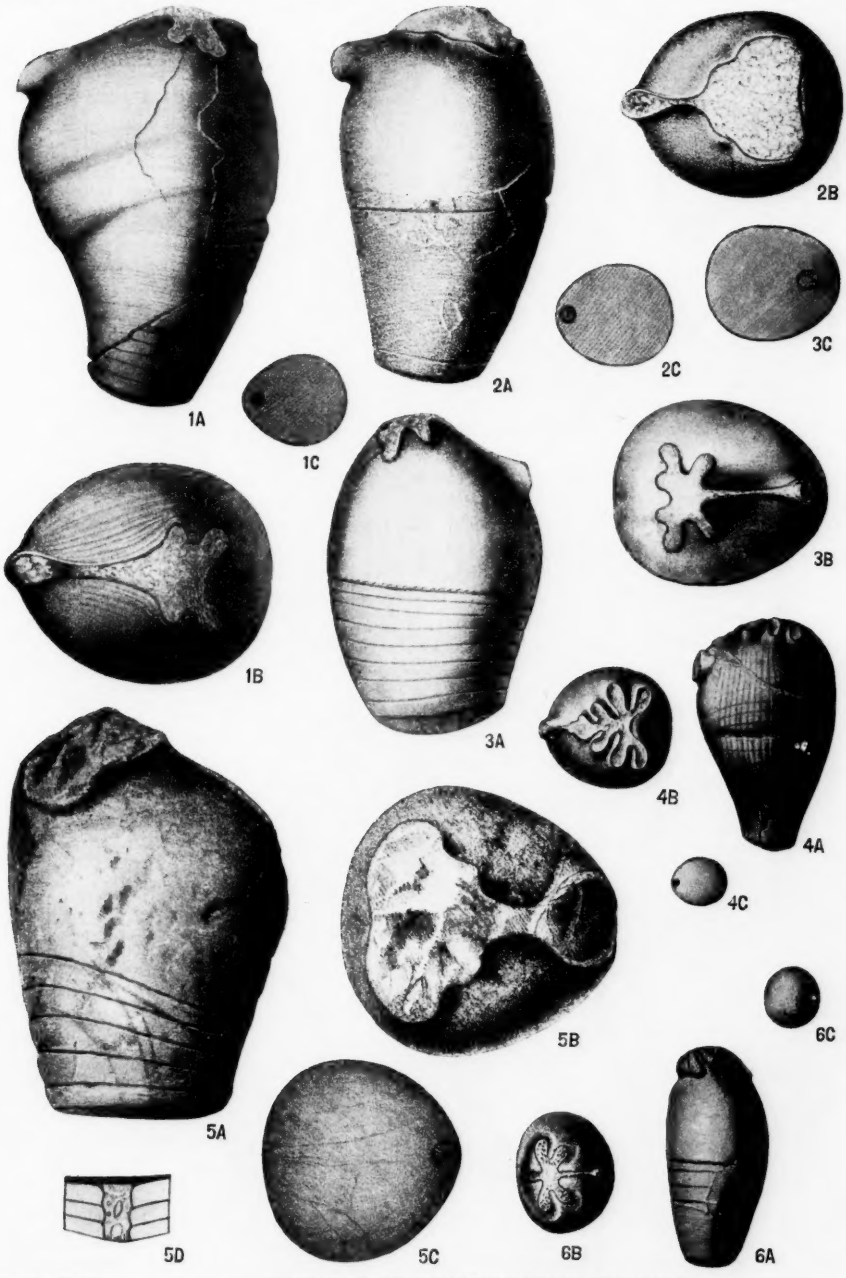

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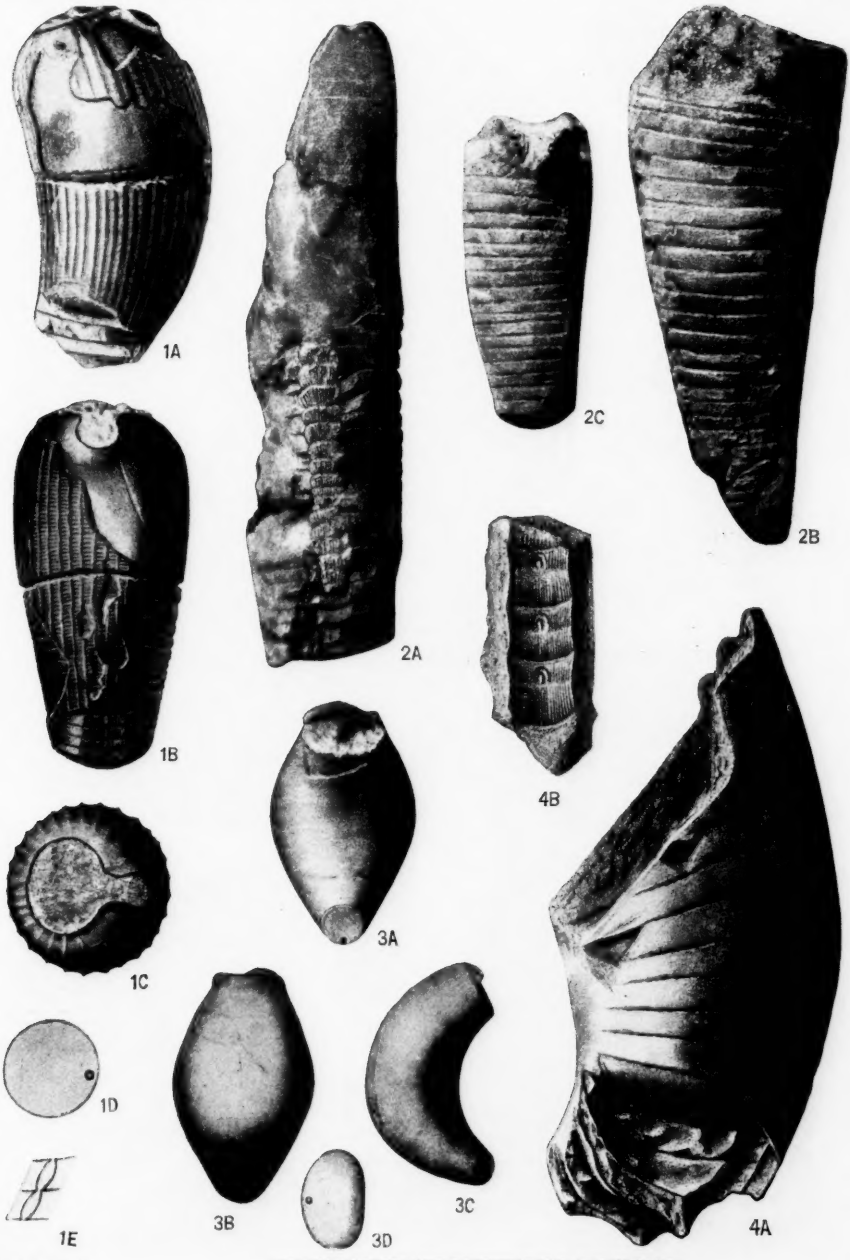
PLATE LI

Figs. 1 A–E. *Clathroceras sulcatum* (Barrande). A, B, lateral views; C, aperture seen from above; D, cross-section showing location of siphuncle; E, vertical section through siphuncle. Bohemia; Syst. Sil. Boheme, pl. 47, figs. 11, 8, 12, 10, 13.

Figs. 2 A–C. *Herkimeroceras subrectum* (Hall). A, ventral view, exposing siphuncle with converging vertical lamellae; B, lateral view of another specimen, C, lateral view of a smaller specimen. Litchfield, Herkimer county, New York; in Keyser member of Basal Lower Devonian. The first two figures are from the originals of figs. 3b and 3c on pl. 69 of Pal. New York, vol. 3, 1861. Fig. 3d was prepared from part of specimen 3b. Specimen No. 2597. American Museum of Natural History.

Figs. 3 A–D. *Gonatocyrtoceras heteroclytum* (Barrande). A, dorsal view; B, ventral view; C, lateral view; D, cross-section showing location of siphuncle, oriented as in fig. 30. Bohemia, Syst. Sil. Boheme, pl. 118, figs. 17, 16, 15, 18.

Figs. 4 A, B. *Blakeoceras llandoveri* (Blake). A, lateral view, with glimpse of siphuncle along lower right margin; B, interior of siphuncle showing vertical striae regarded as corresponding to converging vertical lamellae of other actinosiphonate conchs. Craig-yr-Wyddon, Great Britain; Lower Llandovery member of Middle Silurian. British Fossil Cephalopoda, 1882, pl. 21, figs. 1, 1a.



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ACTINOSIPHONATE AND TROCHOCERIOD CEPHALOPODS

PLATE LII

Fig. 1. *Diestoceras scalare* Foerste. Dorso-ventral vertical section through siphuncle. West-end light-house, Anticosti; Charleston member of Richmond. Specimen No. 2211 Geological survey of Canada.

Figs. 2 A–C. *Perimecoceras contrastans* (Barrande). A, lateral view, with ventral side on right. B, septum viewed from beneath, showing location of siphuncle. C, vertical section of siphuncle, with converging vertical lamellae; segments of siphuncle with concave vertical outlines. Vallon de Slivenetz, Bohemia; Middle Silurian. Syst. Sil. Boheme, pl. 500, figs. 11, 13, 14; size, 0.75 diameter.

Figs. 3 A–C. *Blakeoceras empiricum* (Barrande). A, lateral view with ventral side on right. B, cross-section of conch showing location of siphuncle. C, dorso-ventral vertical section through siphuncle with converging vertical lamellae; segments of siphuncle with concave vertical outlines. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 541, figs. 1, 3, 2; size, 0.50 diameter.

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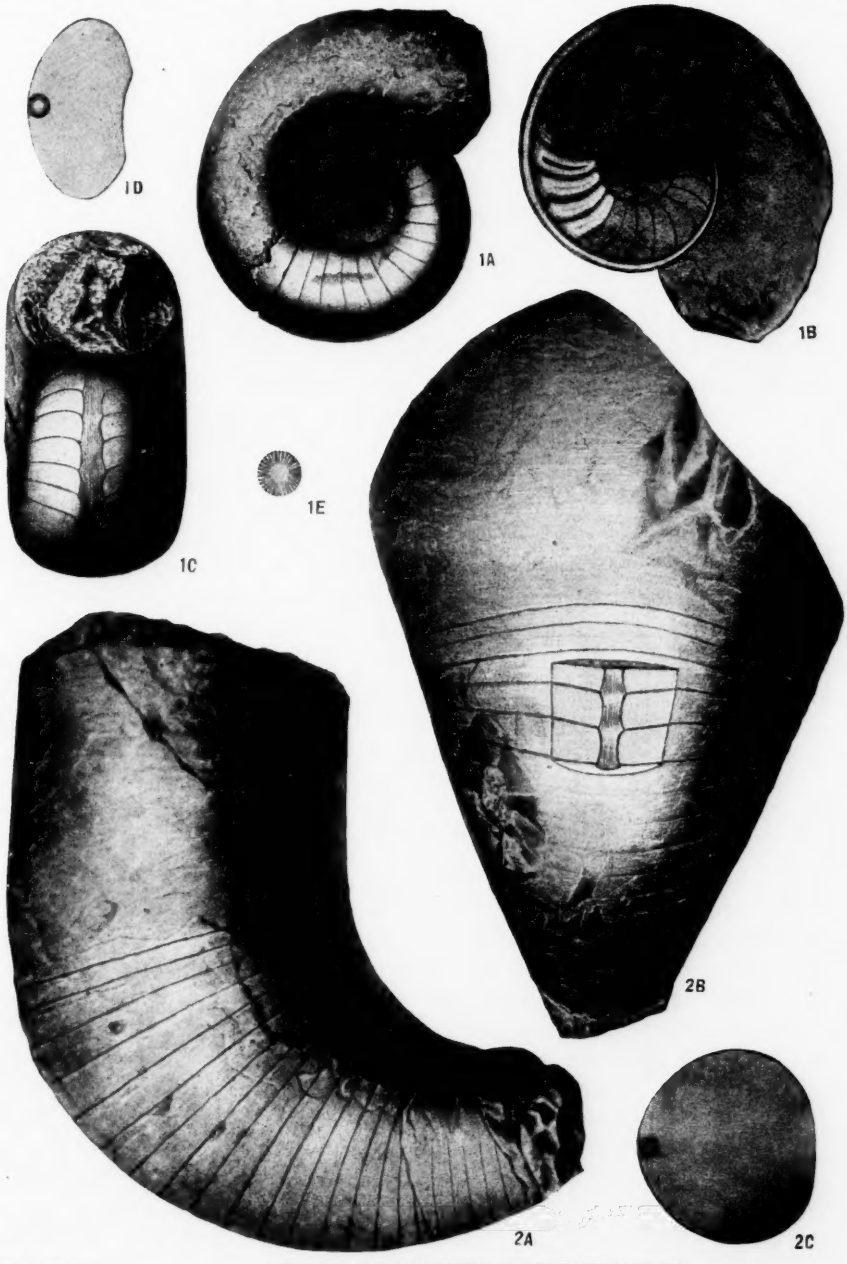
ACTINOSIPHONATE AND TROCHOCEROID CEPHALOPODS

PLATE LIII

Figs. 1 A–E. *Nothoceras bohemicum* Barrande. A, lateral view, showing length of living chamber. B, section parallel to plane of volutions, with siphuncle along convex side, its segments with concave vertical outlines. C, specimen viewed from smaller side of last volution, showing contracted aperture, also siphuncle in contact with ventral side, its segments with concave vertical outlines, and its interior with converging vertical lamellae. D, cross-section of phragmacone, with impressed dorsal zone, showing location of siphuncle. E, cross-section of siphuncle with radiating vertical lamellae. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 13, figs. 1, 2, 3, 5, 6; size, 0.48 diameter.

Figs. 2 A–C. *Turnoceras turnus* (Barrande). A, lateral view with ventral side on left. B, ventral view, with siphuncle exposed along upper part of phragmacone, its segments with concave vertical outlines, and its interior with vertical converging lamellae. C, cross-section showing location of siphuncle. Hlubocep, Bohemia; Middle Devonian. Syst. Sil. Boheme, pl. 483, fig. 1, and 484, figs. 1, 2; size of A, B, 0.48 diameter, of C, 0.40 diameter.



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BRACHIOPODS FROM THE ST. CLAIR LIMESTONE, ARKANSAS

NORMAN L. THOMAS

Received February 2, 1926; published September 29, 1926

This paper describes some Telotremata from the St. Clair Limestone of Silurian age, taken from the outcrops near the city of Batesville, Arkansas. These identifications have been made during the past year and a half in a study of the St. Clair Limestone and its fauna. Bulletin 52 of the United States National Museum has been used as a bibliography and references included in this paper are those which are not to be found in that bulletin. The author hopes to discuss the fauna and to describe other brachiopods in a later paper. He is much indebted to Professor Stuart Weller, Curator Arthur Slocum and Mr. Shepard W. Loman for personal assistance, and to the Walker Museum at the University of Chicago and the Museum at Columbia University for opportunities of examining specimens and using the laboratories.

Rhynchotreta lenta, novum

Shell elongate, cuneiform in outline; valves marked by angular, multiplicating plications, and fine concentric lines of growth. Impunctate. PEDICLE VALVE convex, with anterior outline rounded and posterior acute. A sinus, "V" shape in cross section, extending from the protuberant, smooth beak to the anterior margin of the valve and bounded laterally by two high, coarse plications which diverge anteriorly. The rope-like appearance of these plications due to short plications which originate in the sinus and cross obliquely outward and forward to the flanks. Flanks marked by wavy plications. Foramen apical, deltidial plates large. BRACHIAL VALVE (specimens in-

complete) sub-triangular, wider than long; beak smooth and convex, not protuberant but curved up to the hinge line. Fold extending from the smooth umbo to the anterior margin, wavy, rope-like due to the numerous bifurcations of the main, elevated plication on the fold; bounded on each side by a sinus on the lateral flanks of which faint, outward curving plications become more pronounced and bifurcate. MEASUREMENTS of two pedicle and two brachial valves from four different shells. "A"—pedicle valve length 11.0 mm., width 9.8 mm. "B"—pedicle valve length 10.6 mm., width 10.0 mm. "C"—brachial valve length 6.4 mm., width 8.2 mm. "D"—brachial valve length 5.8 mm., width 8.2 mm.

REMARKS.—Polished sections revealed the hinge plates, the foramen, and a hint of a brachial median septum. Other internal characters did not appear and it is therefore not conclusively proved that these specimens belong to the genus *Rhynchotreta* but the evidence points strongly that way. This species is distinctly different from the other Silurian species in the character of its plications and their arrangement on the valves.

Camarotoechia marginata, novum

Shell subtriangular, width usually equal to or greater than length; plications coarse and tubular, radiating and curving outward from the beak. PEDICLE VALVE with convexity greater longitudinally than laterally, greatest convexity along the anterior portion where the sinus slopes steeply and on the flanks where the lateral slope becomes practically vertical. Sinus broad, shallow and indistinct, and in most cases noticeable only on the anterior half of the valve, containing four or five plications. Plications not bifurcating but radiating from the umbo, those on the flanks curving laterally as well as radiating anteriorly; the two or three outer plications the smallest and shortest, the four plications in the fold being much longer than the others. Umbonal region slightly inflated and arched; the beak extending beyond the hinge line, not incurved, having a

circular foramen at the apex. Hinge areas flat or slightly concave. BRACHIAL VALVE convex, greatest convexity at the margins, umbo sloping flatly in a posterior direction, otherwise valve flat with its fold indistinct except anteriorly where it extends with little curvature to the sinus of the other valve. Fold containing about five plications. The plications at the side of the valve sloping steeply toward the pedicle valve and curving outward. Most of the plications beginning at the umbo but a few in some specimens originating by bifurcation. The median septum showing as a longitudinal fissure or slight furrow on the fold. MEASUREMENTS of two specimens. "A"—length 8.8 mm., width 9.2 mm., thickness 5.6 mm. "B"—length 11.5 mm., width 11.5 mm., thickness 5.8 mm.

REMARKS.—Internal characters distinctly those belonging to this genus, some of the specimens showing the rostral chamber, the hinge plates, the crura, the dental sockets and the median septum. They compare with figure 591 of Zittel's "Textbook of Paleontology" (1913). This species differs from *C. arkansana* in its greater size, greater relative thickness, and the more distinct sinus, coarser and more tubular plications, and in having seven plications to each 5 mm. at a distance of 5 mm. from the beak instead of nine to eleven as in the case of *Arkansana*. The specimens differ from *C. indianensis* in the collections of Walker Museum by having a less distinct fold and sinus, in being slightly flatter and less rotund, and in having five plications on the fold instead of four, and in the presence of four plications in the sinus instead of two and three. They differ from *C. neglecta* in having a very distinct fold and sinus, in having one more plication on the fold and sinus, and in being less rotund. They are very much like the new species being described by John R. Ball, in his paper on the Silurian of Missouri, under the name *C. varians*—variety 4—with four plications in the sinus and five on the fold. It may not be distinct from that species since Ball has found his forms to vary widely. However the St. Clair specimens have a less distinct fold and sinus and probably are different.

Camarotoechia arkansana, noqum

Shell small, subtriangular in outline, acute posteriorly, width usually equal to or less than the length. PEDICLE VALVE gently convex both longitudinally and laterally, steep along the sides. Sinus broad, shallow, indistinct and in most of the St. Clair specimens totally lacking even along the anterior margin. Plications not bifurcating but radiating from the umbo, those on the flanks curving outward, the outer plications on each side the smallest and shortest. Umbo slightly arched; beak extending beyond the hinge line, not incurved but curving outward and downward, with circular foramen at the apex. BRACHIAL VALVE convex or almost flat, greatest convexity at the umbo and along the margins. Beak up curved to the beak of the pedicle valve. Fold obsolete. A depressed longitudinal furrow marking the position of the median septum, and from this furrow the plications diverge on either side. MEASUREMENTS of two specimens. "A"—length 6.6 mm., width 7.0 mm., thickness 2.7 mm. "B"—length 6.2 mm., width 6.3 mm., thickness 2.5 mm.

REMARKS.—Rostral chamber, hinge plates, crura and the median septum have been found. This species differs from *C. marginata* in its smaller size, the relative thinness of the valves, its finer and more crowded plications, there being nine to eleven plications to each 5 mm., of cross section about 5 mm. from the beak. It does not seem to be a young form of the former species since at the same distance from the beak the plications are finer and much more crowded, and the relative thickness of the shell is much less. Besides small specimens with coarser plications have been discovered and thought to be the young of *C. marginata.* It differs from *C. indianensis* and *C. neglecta* in having almost no fold or sinus, and in being much flatter and thinner. It differs from *C. varians* (novum Ball) in lacking, or practically lacking, the fold and sinus, and it differs from Ball's other species in its plano-convexity, and in its acute apex.

Atrypina disparilis (Hall)

Shell small, subplano-convex, outline semi-circular anteriorly and pointed posteriorly, or sub-pentagonal with thin lateral and anterior margins. Beak slightly arcuate, hinge line angular, surface marked by rather strong rounded plications and concentric lines of growth. PEDICLE VALVE strongly convex; with two prominent median plications due to the bifurcating of one plication near the beak; flanks of the valve rather flat and sloping steeply from the median pair of plications to the lateral margins of the valve, two shorter and fainter plications on each of the flanks of the valve. Beak pointed, protuberant, down curved but not encroaching on the brachial valve; foramen apical, circular; deltidial plates covering delthyrium, hinge line less than the greatest width of the shell. BRACHIAL VALVE flat or slightly concave laterally, but gently convex longitudinally. "V" shaped sinus bounded by two moderate prominent plications which originate in front of the beak and bifurcate, and between them a simple median plication intercalated in the sinus and extending almost the whole length of that depression. Plications more rounded and less elevated than those of the opposite valve. Umbo not inflated curved up to hinge line. MEASUREMENTS of two shells. "A"—length 4.0 mm., width 3.5 mm., thickness 1.5 mm. "B"—length 3.6 mm., width 3.4 mm., thickness 1.9 mm.

REMARKS.—The specimens are very similar to descriptions of *A. disparilis* and to those in the collections of Walker Museum. They seem to differ merely in having a greater depression in the brachial valve, and slightly fainter plications. They differ from *Atrypina* ns. described by John R. Ball in being much smaller, more pointed anteriorly, and in having only two plications on the lateral slopes while that species has three, at least in many cases. One specimen of *Atrypina* shows three large plications on the fold of the pedicle valve instead of two, and three on each lateral slope instead of two, and three intercalated in the sinus of the

brachial valve rather than one, and two on each lateral portion of that valve instead of one. Whether this is a new species or merely an aberrant form is uncertain since only one specimen has been found.

Atrypa reticularis (Linnaeus)

Shell subplano-convex, subelliptical, approaching a circular outline, length a little greater than the width, not prominently gibbous, hinge line short and curved, cardinal extremities rounded, surface of each valve marked by fine concentric lines of growth and by twenty-five to thirty fine plications, many of which are due to bifurcations of those originating in the umbonal region. PEDICLE VALVE slightly convex, greatest convexity in the umbonal region and around this the valve is flattened-convex but hardly concave. Beak moderate in size, slightly protuberant, incurved as well as up curved but not prominent. Sinus shallow, broad, indistinct, length not more than that of half the shell, not noticeably produced anteriorly. No cardinal area; hinge line short, curved. BRACHIAL VALVE more convex than pedicle valve, greatest convexity posterior to the middle with the steepest slope posterior and the gentle slope anterior. No fold is indicated, there is no protuberant beak, for the valve slopes steeply to the hinge line under the pedicle beak. MEASUREMENTS of two individuals. "A"—length 14.2 mm., width 13.7 mm., thickness 7.2 mm. "B"—14.6 mm., width 14.3 mm., thickness 8.0 mm.

REMARKS.—The St. Clair specimens should probably be referred to *A. reticularis* variety *Niagarensis*, Nettelroth, since they are comparatively small, with fine plications, and outlines closely simulating the illustrations of that variety. This species is rather rare in the St. Clair Limestone.

Spirifer radiatus (Sowerby)

Shells varying widely in size and considerably in shape, but only a few of the Arkansas specimens more than an inch in length; wider than long, smooth, lacking plications but with both

valves marked by fine radiating, longitudinal stria; subsemicircular in outline, both valves strongly convex. PEDICLE VALVE with the greatest convexity posterior to the middle, the surface sloping abruptly to the cardinal area and rather gently to the lateral and anterior margins, slightly flattened towards the cardinal extremeties. Mesial sinus broad and comparatively shallow, in some specimens rounded in cross section, in others steep on the sides and flat on the bottom; originating on the beak and extending to the anterior margin with a rounded extension. Beak extending out over the cardinal area and curving inward and downward to it. Cardinal area relatively narrow, length a little less than the width of the shell, curving concavely outward toward the beak, the curvature becoming stronger towards the beak; dorsal area triangular, ventral area with practically straight sides. Delthyrium small, triangular. BRACHIAL VALVE with convexity like that of pedicle valve, sloping steeply posteriorly and gently laterally and anteriorly. Mesial fold broad, rounded or flat, well defined, originating at the beak. MEASUREMENTS of two specimens: "A"—length 18 mm., width 21 mm., height cardinal area 2.5 mm., thickness 13 mm. "B" —length 11 mm., width 14 mm., height cardinal area 1 mm., thickness 8 mm.

REMARKS.—The specimens in the St. Clair Limestone are consistently smaller than most of the forms from New York State and Indiana, but differ from them in few other respects, and conform to them in decoration, general shape and character of the cardinal area. They differ from *S. plicatella* in having finer striations, an absence of plications, a less protruding pedicle beak, thinner lateral margins and a greater relative width to the valves. If *S. lineatus*, Sowerby, described on page 151, "Sowerby's Mineral Conchology," Vol. V, 1825, and illustrated on plate 493, is to be regarded as the type for the species, the American specimens described under that name differ considerably from the type. The Arkansas specimens are like the American forms but differ from those shown by Sowerby in having a narrow delthyrium, finer radiating striae and a more rounded outline which is less pointed at the cardinal extremities.

Spirifer splendens, novum

Shell gibbous, valves unequal, hinge line less than the greatest width of shell; surface with two plications on each side of fold and three on each side of sinus, crossed by concentric lines of growth, sinus extended considerably in front. PEDICLE VALVE convex both longitudinally and laterally, greatest convexity in umbonal region, cardinal extremities of valve not flattened. About as long as wide; with deep, wide sinus which extends from the beak to anterior margin. Plications bounding the sinus the most prominent, and the outer ones the faintest and shortest. Beak prominent, protuberant, down curved and incurved nearly to cardinal area. Cardinal area shorter than greatest width of shell, concave, triangular in shape, marked by transverse striae which are continuations of the concentric lines of growth of the two valves. BRACHIAL VALVE less convex than the pedicle valve, slightly wider than long, anterior margin subcircular in outline. Median fold prominent, round in cross section, most arched at umbo but most elevated and prominent along the anterior margin where it meets the lip-like extension of the pedicle sinus. Umbo inflated, beak not protuberant. Two plications on each side of fold, outer ones shorter, less distinct, coalescing with the next longer at the umbo. MEASUREMENTS of two shells: "A"—length pedicle valve 7.5 mm., length brachial 5.8 mm., width shell 7.0 mm., thickness 4.9 mm. "B"—length pedicle valve 6.3 mm., length brachial 5.5 mm., width shell 6.7 mm., thickness 4.7 mm.

REMARKS.—This species differs from *S. sulcatus* in having a more protuberant and rostrate beak, an inflated brachial umbo, and a non protruding brachial beak, in the presence of a long sinus extending well beyond the regular anterior margin of the valve, and in the absence of the rough crenulated appearance. It differs from *S. vaningeni* in the same respects, but is like it in not having a protuberant brachial beak.

Spirifer vaningeni, novum

Shell semi-elliptical in outline, wider than long, gibbous; valves fairly equal, hinge line less than greatest width of shell; surface

with two or three plications on each side of the fold and sinus. Surface marked with a few lines of growth and faint longitudinal striae. PEDICLE VALVE convex, greatest convexity in front of the cardinal area, whole valve convex both longitudinally and laterally, slightly flattened at cardinal extremities. Median sinus broad, moderately deep, rounded in cross section, beginning far out on the beak. Beak protuberant and down curved. Cardinal area shorter than greatest width of shell, triangular, concave, marked with very fine longitudinal striations. Three plications on either side of the sinus, the outer being fainter and shorter. Beak prominent, protuberant, down-curved toward cardinal area. Shell marked by a few coarse lines of growth but not with the crenulated appearance of *S. sulcatus*. BRACHIAL VALVE slightly less convex than the pedicle valve, wider than long. Median fold broad, most arched at the umbo. Umbo slightly inflated but with beak not protuberant. Two plications on either side of fold, the outer the fainter and shorter. MEASUREMENTS of one pedicle and one separate brachial valve: "A" —pedicle valve length 7.3 mm., width 9.4 mm. "B"—brachial valve length 8.3 mm., width 12.5 mm.

REMARKS.—This species differs from *S. splendens* in having the sinus only slightly produced anteriorly, and in having a less prominent beak. This species is named in honor of Professor Van Ingen who described many St. Clair trilobites a quarter of a century ago.

Spirifer (Delthyris) sulcatus, Hisinger

Shell semi-hexagonal to semi-elliptical, wider than long, gibbous; valves fairly equal, hinge line more or less extended; surface with four to six plications on each side of the median fold and sinus, crossed by strong crenulated concentric lamellae and marked longitudinally by very fine striae. Shell exceedingly variable as to length of hinge line, the sharpness or rounding of the lateral cardinal extremities, the amount of projection of the beaks and the inclination of the cardinal area. PEDICLE VALVE convex, greatest convexity directly in front of the cardinal area, flattened toward the cardinal extremities. Median sinus orig-

inating far out on beak, broad, moderately deep, flattened in the bottom and steep on the sides, especially anteriorly. Three or four distinct plications on either side of sinus, the other plications being low and indistinct and short. Beak extending a short distance over the cardinal area and arching sharply to that area. Cardinal area long, exhibiting intermediate variations between the cases where it is a little shorter than the greatest width of the shell and other cases where it makes the greatest width and is drawn out laterally a little beyond the regular contour of the valves; width moderate, ventral border an obtuse angle with the area curving slightly in concave fashion toward the pedicle beak, dorsal border straight. Delthyrium triangular and moderately broad. BRACHIAL VALVE convex, flatter posteriorly than the pedicle valve but more elevated anteriorly. Median fold moderately broad, rounded in cross section. Beak extension under the cardinal area slightly less prominent than that of pedicle beak. Three distinct and one short indistinct plication on each side of fold. MEASUREMENTS of two shells: "A"—length 8 mm., width 11 mm., thickness 6 mm. "B"—length 7 mm., width 9 mm., thickness 4 mm.

REMARKS.—It differs from *S. crispus* in the prominent plications and its roughly lamellate or rugose surface. It differs from *S. crispatus* in being less elevated, having a greater extension along the hinge line, and in having more than three plications on each lateral slope.

Cyrtia exporrecta, Wahlenberg

Shell semi-pyramidal, hinge line almost as long as the greatest width of the shell, surface smooth, without plications but with fine, crowded radiating striations which are visible without the aid of a lens, wider than long, greatest height comparable to the length, impunctate. PEDICLE VALVE convex, semi-pyramidal, forming an obtuse posterior apex which approaches a right angle, sloping steeply to the sharp lateral and anterior edges. Median sinus extending from the apex to the front where it extends slightly beyond the regular contour, sub-"v" shaped or rounded

in cross section. Both the sinus and the flanks of valve marked by distinct but fine radiating striations and also by a few concentric lines of growth. Beak slightly arched over cardinal area. Cardinal area large and broad, triangular, almost vertical, sharply defined on margins, brachial border straight and pedicle border a "v" shape which is obtuse but approaches a right angle; brachial half flat, pedicle half concavely arched outward to the beak in most cases, in other cases flat; height of area equal to about half its width; lines of growth crossing the area from one side to the other as straight parallel lines. Pseudodeltidium elongate, isosceles-triangular in outline, convex in relief, with oblique, circular foramen which is not well preserved in most St. Clair specimens. BRACHIAL VALVE subsemielliptical in outline, uniformly convex over whole valve, with a little flattening at the cardinal extremities and a decided arching of the beak out under and up to the straight dorsal margin of the cardinal area. Median fold originating at the point of the beak, well defined, moderately broad, depressed longitudinally along the middle, sides steep. MEASUREMENTS of two specimens: "A"—length 13 mm., width 17 mm., height of cardinal area 7 mm., width of pseudodeltidium at hinge 2 mm. "B"—length 10 mm., width 15 mm., height of cardinal area 6 mm., width pseudodeltidium 1.5 mm.

REMARKS.—This species is variable in shape and character of the cardinal area, in the shape of the fold and sinus as well as in the size of the shells. It differs from *C. myria* (*arrecta*) in having a slightly less elevated and broader concave cardinal area, and the height of the shell about equal to its length. It differs from *C. cliftonensis* in having a cardinal area with a greater relative width and a more obtuse ventral border to the area. It also appears that the pseudodeltidium is wider. John R. Ball reports the finding of a specimen almost identical with these in his studies of the Silurian of Missouri. The St. Clair forms are very similar to some of the specimens from the Wenlock Limestone of England and from the Silurian of Gotland.

Homeospira cf. apriniformis, Hall

Shell inflated, length approximately equal to width, subpentagonal in outline, each valve marked by twenty to twenty-six moderately fine plications, surface decorated with very fine anastomosing lines which cross the plications obliquely. PEDICLE VALVE strongly convex, greatest convexity on umbonal region, beak protruding and upcurved with a tiny round foramen at apex. Sinus broader than most of the grooves noted in the various species of this genus; with about six faint plications on the sloping flanks of sinus, rounded in cross section, bounded by most distinct plications, eight to eleven plications on each side of the sinus. Hinge area short, curved. Anterior margin at contact of valves slightly depressed where the sinus and fold meet. BRACHIAL VALVE convex, umbonal region slightly less inflated than that on the other valve, beak not protuberant but closely folded into hinge line. Fold indistinct, containing about eight plications with a very faint longitudinal furrow between the middle pair of plications, a few with fold practically absent but with a more distinct longitudinal furrow. Surface marked by twenty to twenty-six plications. Internal characters not determined. MEASUREMENTS of one individual—length 8.7 mm., width 8.9 mm., thickness 6.3 mm.

REMARKS.—Only one perfect specimen and a few immature forms have been studied. These are characterized by their inflation, the presence of the broad pedicle furrow on the moderately wide indistinct fold, the fine plications, the curved anterior margin and the obtusely pointed posterior end. The specimens from the St. Clair Limestone differ from (a) *H. schucherti* in being wider, thicker, having four plications in the pedicle sinus instead of two, and having none in the brachial groove, ten to twelve plications on each side of the sinus instead of seven; (b) from *H. schucherti-elongata* in being wider, thicker, having ten to twelve plications on each side of the sinus instead of eight; (c) from *H. pisum beecheri* in being wider, thicker, much more convex, with ten to twelve plications on each side of the groove, pedicle sinus much broader and with four plications instead of

two; (d) *H. pisum* in being wider, having nearly twice as many plications on each side of groove; (e) *H. evax* in being more pentagonal, wider and less elongate, having finer plications, being less convex in the umbonal region of brachial valve; (f) from *H. apriniformis* in being less acute posteriorly, slightly wider, with a deeper sinus on the pedicle valve. The specimens are nearest to this species of any described. It differs from (g) *H. immatura* in being much wider and much thicker, plications less distinct; (h) from *H. subcircularis* in being thicker, less prominent plications and more of them; (i) from *H. sobrina* in being wider, having more numerous and less prominent plications. When more specimens are discovered and studied it is possible that a new species may be named, but due to the great variability characteristic of the species under this genus, and to the lack of sufficient material it seems best to merely refer to species *Apriniformis.*

Nucleospira clairensa, novum

Shell biconvex to planoconvex, anterior border semicircular, posterior border obtusely angular in outline, length and width approximately equal, surface marked by fine concentric lines of growth. PEDICLE VALVE strongly convex, with an arched, convex, longitudinal ridge or fold containing the suggestion of a furrow and a faint depression anteriorly. Flanks of valve sloping away steeply from this ridge to the lateral margins and forward to the circular anterior margin. Cardinal extremities rounded and slightly flattened. Hinge line shorter than the greatest width of the shell, curved or forming an obtuse angle. Beak pointed, extending beyond the opposite valve, downcurved but neither covering the delthyrium nor arching over the brachial valve; delthyrium entirely covered with flat or gently convex deltidial plates, except for the small apical, circular foramen. BRACHIAL VALVE slightly convex to subplano, greatest convexity posterior to the middle; beak not protuberant but folding to the hinge line. A narrow, shallow furrow extends from the umbonal region toward the anterior margin but in most

cases this depression widens and becomes obscure anteriorly. MEASUREMENTS of three individuals: "A"—length, 8.0 mm., width 7.8 mm., thickness 3.7 mm. "B"—length 7.9 mm., width 8.5 mm., thickness 3.8 mm. "C"—length 3.5 mm., width 3.6 mm., thickness 1.3 mm.

REMARKS.—The specimens range from very small individuals to those 8 mm. in length. The shells are very abundant in the lower part of the St. Clair Limestone. Internal characters were not observed. This species differs from *H. concentrica, concinna, elegans, pisiformis* and *ventricosa* in being distinctly planoconvex in form.

Hyattidina? cf congesta

Shell small, subpentahedral, rostrate, short, with curved hinge line; long sinus on pedicle valve extending beyond the regular contour of the shell. PEDICLE VALVE strongly convex, greatest convexity at the umbo. Flanks of the valve sloping very steeply to the lateral margins, length of shell greater than width. Sinus roughly half of valve, broad, rounded in cross section, originating far out on the beak and extending anteriorly where it is considerably protuberant. Beak rostrate, out curved and down curved, covering the delthyrium. Hinge line shorter than the greatest width of the shell, slightly curved; cardinal area concave. Surface marked by very fine lines of growth and two plications each side of the sinus. BRACHIAL VALVE strongly convex, subequidimensional. Fold very prominent, rounded in cross section, beginning far out on umbo. A very faint plication on each flank of the valve. Beak not as prominent as pedicle beak but protuberant. MEASUREMENTS of one specimen: —length 5.1 mm., width 4.7 mm., thickness 4.3 mm.

REMARKS.—Only one complete specimen and a number of fragments are at hand and the determination is rather questionable. It differs from *H. congesta* in its smaller size, the apparent lack of longitudinal striations, greater rotundity and greater relative prominence of the fold and sinus.

Meristina lepida, novum

Shell small, wider than long; subpentagonal to subelliptical in outline, both valves considerably inflated, the convexity of the brachial valve greater than that of the pedicle valve; beaks small, about equal, closely incurved and covering the pedicle opening. Shell smooth with very faint concentric lines of growth. PEDICLE VALVE with a wide rounded sinus extending from the center of the valve to the anterior margin and deepening rapidly anteriorly. Umbonal region slightly inflated; beak small and incurved. Median septum extending at least half the length of the valve. Other internal characters unknown. BRACHIAL VALVE more convex than the opposite valve, the greater convexity being lateral rather than longitudinal. Fold indistinct and rounded, conforming well to the rotundity of the rest of the valve. Umbo but slightly inflated, beak small and closely incurved. A short median septum is the only internal character noted. MEASUREMENTS of three shells. "A"—length 5.5 mm., width 6.2 mm., thickness 3.8 mm. "B"—length 6.0 mm., width 6.7 mm., thickness 3.5 mm. "C"—length 5.2 mm., width 6.2 mm., thickness 2.6 mm.

REMARKS.—These shells differ from *Merista parva* in lacking the "shoe lifter process" and in being broader and having a more pronounced and more steeply curved sinus. Their generic position is not without question, since very little is known concerning the internal characters. They differ from *Meristina maria* in being smaller, having a wider sinus and more nearly equal beaks. They differ from *M. rectirostra* in having less pointed and less prominent beaks, a hidden pedicle opening and a greater breadth. They differ from *M. blancha* in having more nearly equal beaks and a wider sinus as well as being smaller in size. They differ from *M. tumida* in being smaller, wider, less rugose, and in having more nearly equal beaks, and a hidden foramen. They differ from *Meristella? didyina*, Dalman, in the equality of the beaks and the broader more noticeable sinus. They differ from *Meristella vultur*, Barrande, "Silurian System," volume V,

plate 12, in the greater width, the equality of the valves and the subtruncated appearance of the anterior border of the brachial valve.

Merista parva, novum

Shell small, widely variable; subtriangular, subpentagonal or subelliptical in outline, in most cases with both valves considerably inflated, convexity of the valves about equal; pedicle valve slightly protuberant, out curved and down curved to the narrow indistinct cardinal area. Anterior portion generally less inflated than the posterior half. Since the shell is exceedingly variable it will be best to describe under varieties rather than to make a complete general description. PEDICLE VALVE, strongly convex, smooth or with faint concentric markings. Hinge area curved, narrow. Umbonal region moderately prominent. Beak small and incurved, apex perforated by a circular foramen which is often concealed in many of the specimens. Two divergent lines in some specimens extending for half the length of the shell indicate the attachment of the internal concave plate, or spondylium, which has been known as the "shoe lifter process" from the character of its shape. This process is broader and less deeply intrenched than the process in *Merista tennesseensis.* Variety fossula: well inflated, subpentagonal to subtriangular in outline, anterior border subtruncate; sinus extending from the beak, between the diverging surface lines of the "shoe lifter process" to the anterior margin where it becomes steeper and more marked. Variety rotunda: more inflated than the other varieties, more elliptical; without sinus, or with only the suggestion of one but nevertheless having the "shoe lifter process;" otherwise simulating fossula. Variety pentagona: less inflated than the former two, noticeably pentamerous in outline, with a slightly flattened anteriorly sloping area in place of a sinus, anterior margin subtruncate. Variety elliptica: comparable to pentagona in inflation, from which it differs merely in being more elliptical or subcircular in outline, in having a curved rather than a subtruncate anterior margin, and in being more evenly convex over the whole valve. BRACHIAL VALVE strongly

convex, greatest convexity in front of beak in umbonal region, smooth except for a few concentric lines of growth, lateral areas sloping steeply at the sides; a median septum more or less strongly developed along the middle of the inconspicuous or obsolete fold often showing on the surface as a faint line running from the brachial beak toward the anterior margin. Beak merely inflated and not protuberant. MEASUREMENTS of three specimens of each variety:

	LENGTH			WIDTH			THICKNESS		
	mm.			*mm.*			*mm.*		
Variety fossula.....	7.0	5.5	4.5	5.8	5.0	3.6	4.7	3.7	3.0
Variety rotunda.....	5.2	5.9	5.4	4.0	4.6	4.2	3.0	4.1	3.5
Variety pentagona....	5.6	4.8	5.2	5.3	4.4	4.5	3.5	2.8	3.2
Variety elliptica.....	6.3	5.4	6.2	5.0	5.2	5.3	3.2	3.0	3.8

REMARKS.—The varieties noted can be distinguished only with difficulty, except by the use of the lens, due to the small size of the shells, the variability of forms, and the general similarity of the varieties. There is some gradation between varieties but in general the differences are distinct and fairly constant. The descriptive names "fossula, rotunda, pentagona, elliptica" are merely for reference within this paper, since these names indicate the main characteristic of each and at the same time serve better than numbers. *Merista parva* differs from *M. tennessensis* in being consistently smaller or dwarf, and in having a less sharply pointed beak, and a broader, shallower spondylium. In earlier studies of the St. Clair fauna these shells are the ones which probably were listed as *Whitfieldella nitida, oblata, cylindrica* and *intermedia*. Certainly many of these shells do not belong to that genus but are *Meristas*. The spondylium has been found in varieties fossula and rotunda but not in pentagona and elliptica. Therefore all of these similar shells have been listed as *Merista* with "fossula" as the type. It is possible that there are four species included under the name *M. parva*.

PLATE LIV

Figures of Some St. Clair Telotremata

Locality: near Batesville, Arkansas.

Formation: St. Clair Limestone-Silurian.

Size of figures: 1½ enlarged from natural size.

Fig. 1. *Rhynchotreta lenta*, novum. Pedicle valves.

Fig. 2. *Camarotoechia marginata*, novum. Left brachial valve, middle side view, right pedicle view.

Fig. 3. *Camarotoechia arkansana*, novum. Brachial views.

Fig. 4. *Atrypina disparilis* (Hall). Brachial views.

Fig. 5. *Spirifer vaningeni*, novum. Left pedicle view, right brachial view of different specimen.

Fig. 6. *Spirifer (delthyris) sulcatus*, Hisinger. Left pedicle view, right brachial view.

Fig. 7. *Hyattidina? congesta* (Conrad). Left pedicle view, right posterior view.

Fig. 8. *Spirifer splendens*, novum. Left brachial view, right pedicle view.

Fig. 9. *Homeospira cf apriniformis*, Hall. Left brachial view, right pedicle view.

Fig. 10. *Cyrtia exporrecta*, Wahlenberg. Left brachial view, middle cardinal area, right pedicle view.

Fig. 11. *Nucleospira clairensis*, novum. Left pedicle view, right brachial view.

Fig. 12. *Merista parva*, novum-variety elliptica. Left brachial view, middle brachial view, right pedicle view.

Fig. 13. *Meristina lepida*, novum. Left brachial view, right pedicle view.

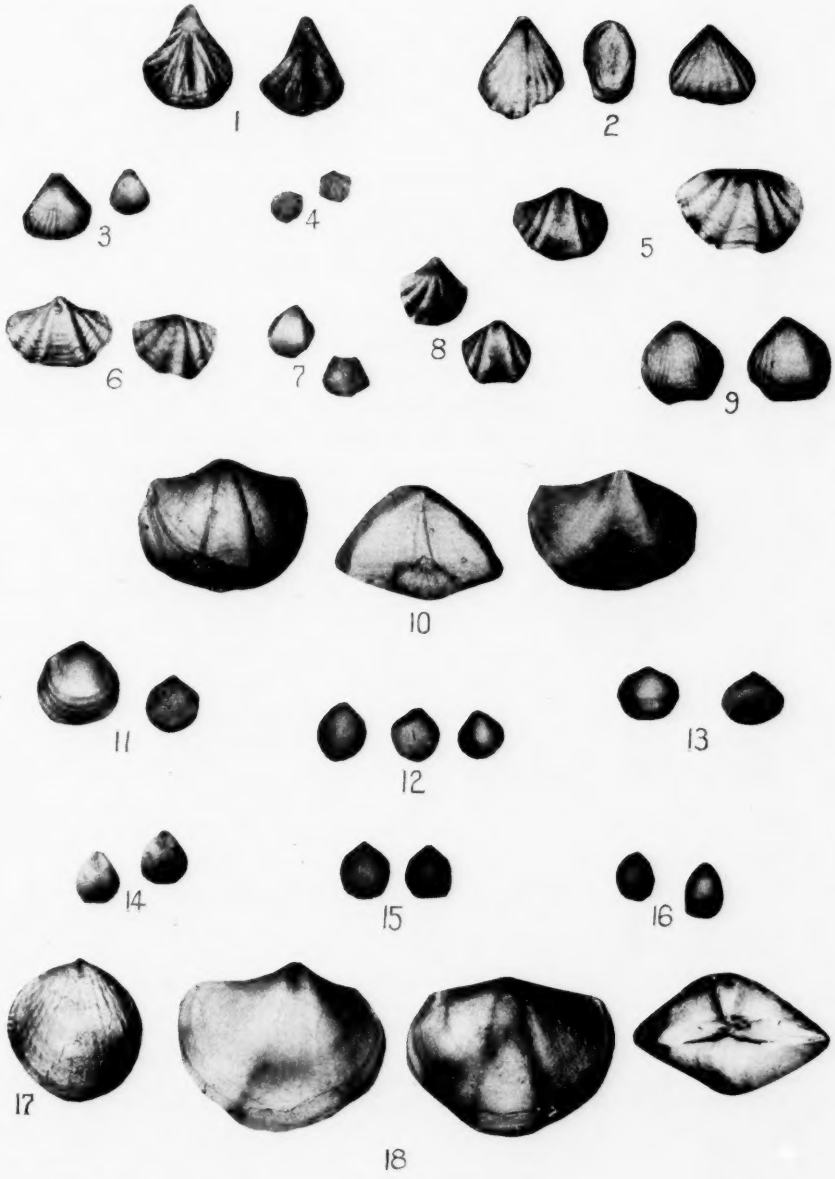
Fig. 14. *Merista parva*, novum-variety fossula. Pedicle views.

Fig. 15. *Merista parva*, novum-variety pentagona. Left brachial view, right pedicle view.

Fig. 16. *Merista parva*, novum-variety rotunda. Pedicle views.

Fig. 17. *Atrypa reticularis* (Linnaeus). Brachial valve.

Fig. 18. *Spirifer radiatus* (Sowerby). Left pedicle view, middle brachial view, right cardinal area.



NORMAN L. THOMAS ST. CLAIR BRACHIOPODS

NOTES ON THE PREPARATION OF HYDROGEN SULFIDE AND HYDROGEN IODIDE

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Received July 12, 1926

During the semester just closed a class of approximately 70 students in qualitative analysis used the method for preparing hydrogen sulfide recommended by Henwood, Garey, Goldberg and Field.[1] The results were so satisfactory it seems desirable to call the attention of fellow-chemists to them.

According to the authors a mixture of paraffin wax and sulfur, preferably with finely divided ignited asbestos[2] added, is packed into a 15 cm. test tube provided with a singly-bored cork and delivery tube, and then heated with a small bunsen flame. The reaction is probably represented thus: $C_nH_{2n+2} + (n + 1)S = nC + (n+1)H_2S$. It is stated that 10 cc. of charge yield about 2000 cc. of hydrogen sulfide, that the evolution of gas ceases within one minute after the flame is removed, and that when the charge has been exhausted the residue may be cleaned out easily, leaving the apparatus ready for refilling.

These statements can be confirmed from our class experience. It has been found that for economy and convenience the method is superior to the use of individual generators of the ordinary type, to apparatus like that of Kipp, and even to the so-called automatic or semi-automatic generators made to supply a whole laboratory.

Several near-accidents from burns occurred. In every case these were due to the use of too small delivery tubes or too large

[1] Henwood, Garey, Goldberg and Field. *J. Franklin Inst., 199*, 685-6 (1925).

[2] A commercial preparation based upon the interaction of sulfur and paraffin, in the presence of asbetos, is now upon the market. In our case, however, students prepared their own charges from "Parowax," flowers of sulfur and asbestos fibre.

flames. If tubes of 6 to 8 mm. inside diameter, and flames not more than 2 to 4 cm. high, are employed, the danger practically disappears.

In the course of an investigation some years ago[3] it was necessary to use gaseous hydrogen iodide for a number of weeks. This was generated by the conventional method, *i.e.*, the treatment of iodine and phosphorus with water. Unfortunately, however, many explosions occurred during the work, entailing great loss of time and destruction of apparatus. It was assumed that these explosions were due to phosphorus hydrides formed as byproducts. A search of the literature suggested that the method of Etard and Moissan[4] be tried. This consisted of heating iodine and rosin (colophonium) together gently, in the presence of broken glass, and leading the product of reaction through a purifying train consisting of a reflux condenser and an empty U-tube.

Difficulties due to explosions ceased, and the studies that were about to be abandoned were pushed to a successful conclusion.

It is believed that the methods for generating hydrogen sulfide and hydrogen iodide outlined above are worthy of more general recognition and use.

[3] Ebaugh, Dissertation, Univ. of Penna. (1901).
[4] Etard and Moissan, *Bul. Soc. Chim.* [2] *34*, 69.

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